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भाग 2 उपयोगी ट्रांसमीटर - ए3ई, एफ3ई, अथवा जी3ई उत्सर्जन

(*पहला पुनरीक्षण*)

Indian Standard

METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN THE MOBILE SERVICES

PART 2 TRANSMITTERS EMPLOYING A3E, F3E OR G3E EMISSIONS

(*First Revision*)

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NATIONAL FOREWORD

This Indian Standard (Part 2) (First Revision) which is identical with IEC Pub 489-2 (1991) 'Methods of measurement for radio equipment used in the mobile services : Part 2 Transmitters employing A3E, F3E or G3E emissions', issued by the International Electrotechnical Commission (IEC), was adopted by the Bureau of Indian Standards on the recommendation of Radio Communications Sectional Committee, LTD 20 and approval of the Electronics and Telecommunication Division Council.

This standard was originally published in 1984 and was largely based on IEC 489-2(1978). Consequent upon the revision of IEC 489-2(1978) as IEC 489-2(1991), this standard is now being revised to align it with IEC 489-2

(*Continued on third cover page*)

Indian Standard
METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN THE MOBILE SERVICES
PART 2 TRANSMITTERS EMPLOYING A3E, F3E OR G3E EMISSIONS
(First Revision)

1. Scope

This standard refers specifically to mobile radio transmitters having audio-frequency bandwidths generally not exceeding 10 kHz for the transmission of voice and other types of signals, using:

a) angle modulation (phase/frequency modulation), or
b) double-sideband amplitude modulation with full carrier.

This standard is intended to be used in conjunction with IEC 489-1. The supplementary terms and definitions and the conditions of measurement set forth in this standard are intended for type tests and may be used also for acceptance tests.

2. Object

The object of this standard is to standardize the definitions, the conditions and the methods of measurement used to ascertain the performance of transmitters within the scope of this standard and to make possible a meaningful comparison of the results of measurements made by different observers and on different equipment.

3. Supplementary terms and definitions

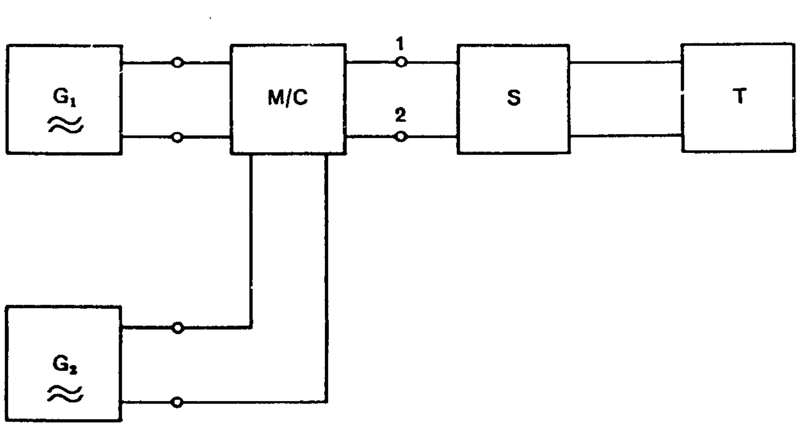
For the purpose of this standard, the following supplementary definitions apply.

3.1 *Input simulation network* (see figure 1, page 8)

A weighting network which modifies the characteristics of an audio-frequency generator so that it simulates the amplitude/frequency characteristics of a device which produces an electrical input signal as a result of a physical change.

3.2 *Rated radio-frequency output power*

The power specified by the manufacturer which, under specified conditions of operation, should be available at the transmitter output terminals when the latter are connected to a specified load.



Legend
G₁, G₂ = audio-frequency generators
M/C = matching or combining network (where required)
S = input arrangement
T = transmitter under test

Note. — S may be a simulation network (see 3.1), an impedance matching network, through connection, or any other specified network.

FIG. 1. — Input-signal measuring arrangement.

3.3 *Modulation depth*

For double-sided amplitude modulation, the modulation depth, in percent, is given by the following:

$$\text{modulation depth} = \frac{(V_{max} - V_{min})}{(V_{max} + V_{min})} \times 100\%$$

where:

V_{max} is the peak-to-peak voltage at the crest of modulation
V_{min} is the peak-to-peak voltage at the valley of modulation

3.4 *Maximum permissible frequency (or phase) deviation*

The value to which the peak frequency (or phase) deviation shall be limited by an agreed convention for a particular class of service.

4. Standard test conditions

Unless otherwise specified, all measurements shall be performed under the general test conditions stated in IEC 489-1 and the supplementary test conditions given hereafter.

5. Supplementary test conditions

5.1 *Input-signal arrangements, modulation limiting and pre-emphasis for transmitters having accessible antenna terminals*

5.1.1 *Input-signal source*

The input-signal source shall consist of one or more audio-frequency generators connected to the transmitter input terminals as shown in figure 1.

5.1.2 *Input-signal voltage*

The audio-frequency input-signal voltage is the voltage across terminals 1 and 2 of the arrangement shown in figure 1. The input-signal voltage should be expressed in terms of the individual voltages of this signal.

5.1.3 *Standard test modulation*

The modulation due to a sinusoidal input signal of 1000 Hz at a level to produce:

- a modulation depth of 60%;
- 60% of maximum permissible frequency (or phase) deviation.

5.1.4 *Standard input-signal voltage*

The input voltage required to produce the standard test modulation.

5.1.5 *Modulation limiting*

The modulation limiter, if present, shall be adjusted for normal operation unless otherwise specified.

5.1.6 *Pre-emphasis*

Pre-emphasis networks, if included in the transmitter, shall be operative unless otherwise specified.

5.2 *Output-signal measuring arrangements for transmitters having accessible antenna terminals*

Note. — In this standard, the term "antenna" is synonymous with "aerial".

5.2.1 *Test load*

A non-radiating load, with an impedance and power rating specified by the transmitter manufacturer, to replace the antenna including any associated transmission line when the transmitter is being tested.

5.2.2 *Connections to the measuring equipment*

Care shall be taken to ensure that the measuring equipment and any coupling devices do not adversely affect the transmitter loading conditions.

5.3 *Output-signal measuring arrangements for transmitters without accessible antenna terminals*

The test load shall be the antenna supplied by the manufacturer. For absolute measurements, a test site equipped with radiation measurement instruments shall be used.

For relative measurements, a radiation coupling system, for example a coupling device having stable characteristics over the range of measurement frequencies, shall be used. In this case, the output terminals of the coupling device shall be treated as the output terminals of the transmitter.

5.4 *Limitation of the measuring audio-frequency band*

Because some properties, for example noise and audio-frequency harmonic distortion, depend upon the audio-frequency bandwidth of the test equipment, reproducible results can be obtained only when the band of audio-frequencies occupied by the demodulated signal is restricted to specified limits.

This restriction may be accomplished by means of a band-limiting filter preceding any audio-frequency measuring device. The filter may be incorporated within the measuring equipment. When measuring residual hum and noise, only the low-pass portion of the filter need be specified.

6. Characteristics of the measuring equipment

Recommended characteristics of the measuring equipment are given in appendix A.

SECTION TWO — METHODS OF MEASUREMENT

7. Frequency error

7.1 *Definition*

Frequency error is the difference between the unmodulated carrier frequency and the *assigned frequency.* The frequency error is expressed in parts per 10^6 or in hertz. For the purpose of this measurement, the assigned frequency is any one of the nominal frequencies.

Note. — This definition is in conformity with the general definition of frequency error in section two of IEC 244-1. *Assigned frequency* is defined in the International Telecommunication Unions (ITU) Radio Regulations.

7.2 *Method of measurement*

The frequency error is determined by measuring the carrier frequency in the absence of modulation.

The carrier frequency may be measured with any suitable measuring device with an accuracy that is at least ten times more precise than the frequency tolerance given in the equipment specification.

If required, the measurements may be repeated on each channel for which the transmitter is equipped to operate.

8. Terminal radio-frequency power

This clause is applicable to transmitters equipped with suitable antenna terminals.

8.1 *General*

The terminal radio-frequency output power of a transmitter may contain:

- a carrier component (see 8.2);
- modulation components determining transmission quality (see clauses 12, 13 and 14);
- other modulation components, for example those contributing to the adjacent channel power (see 8.5);
- spurious narrow-bandwidth components (see 8.3);
- noise, both inside the band (see clause 16) and outside, where it is called spurious transmitter noise (see 8.4), and
- inter-transmitter intermodulation products (see clause 11).

Measurements are normally made at the antenna terminals. Additional measurements may be made at the audio, control and power terminals using specified terminations.

8.2 *Carrier power*

8.2.1 *Definition*

The average power supplied to a transmission line by a transmitter during one radio-frequency cycle in the absence of modulation.

Note. — This definition is in conformity with that given in the ITU Radio Regulations. In this standard, the transmission line may be replaced by a test load.

8.2.2 *Method of measurement*

Measure the output power in the absence of modulation. Any convenient method which gives an accuracy of at least ± 10% may be used.

If required, the measurement may be repeated on each channel for which the transmitter is equipped to operate.

8.3 *Spurious narrow-bandwidth radio-frequency components*

8.3.1 *Definition*

Spurious narrow-bandwidth radio-frequency components include harmonic and non-harmonic components and parasitic components that are usually characterized by a signal having a dominant component at a discrete frequency or in a narrow band of frequencies.

Components in the immediate vicinity of the necessary band, which are the result of the modulation process for the transmission of information, are excluded.

8.3.2 *Method of measurement at the antenna terminals*

a) Connect the equipment as illustrated in figure 2, page 12.

b) With the transmitter operating at the carrier power level measured in 8.2, adjust the frequency of the selective voltmeter (10) to the transmitter carrier frequency and adjust the band-rejection filter (8) to produce a minimum deflection of the selective voltmeter.

c) Adjust the frequency of the selective voltmeter to the first spurious narrow-bandwidth component. Record the frequency and the deflection of the selective voltmeter.

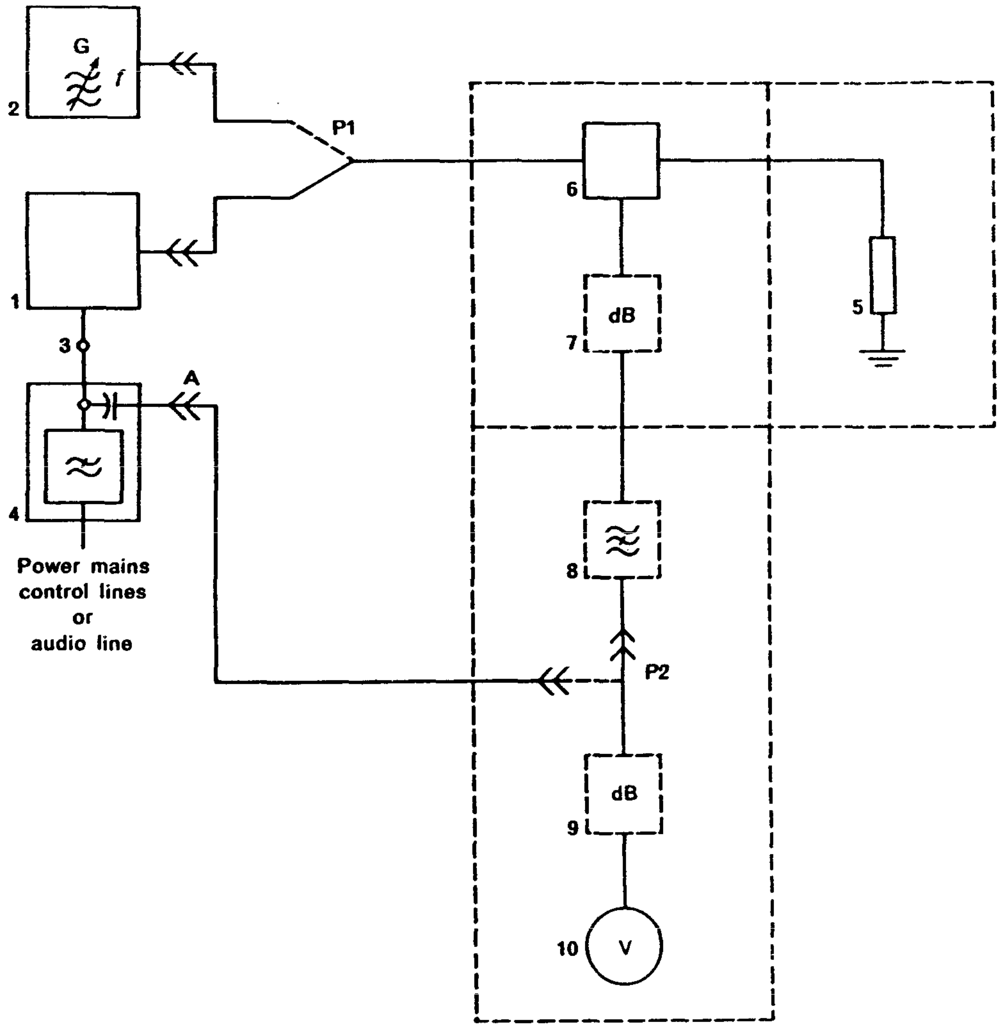
d) Repeat the measurements for each spurious narrow-bandwidth component in the specified frequency range.

Calibration procedure

If the absolute power level of each of these spurious emissions needs to be known, calibrate each deflection as follows:

e) Replace the transmitter by the auxiliary generator (2) at point (P1) and adjust it to operate successively at the centre frequency of each of the spurious narrow-bandwidth components. At each frequency, adjust the auxiliary generator output and the scale of the selective voltmeter, as necessary, to obtain the same deflection as recorded in steps *c)* and *d)* or a known ratio thereof. Record this ratio, the generator output voltage, the scale change and the input impedance of the measuring arrangement.

f) Calculate the power of the spurious narrow-bandwidth radio-frequency component from the values recorded in step *e)*.



Legend

1 = transmitter under test
2 = radio-frequency signal generator
3 = power mains, control lines, or audio line terminals
4 = line-stabilization network
5 = test load
6 = coupling device (may be incorporated in the test load)
7 = isolating pad (may be incorporated in the test load)
8 = band-rejection filter (if needed)
9 = isolating pad (if needed)
10 = selective voltmeter

Note. — The standing wave ratio presented by the test arrangement at point (P1) should not exceed 1.4 for any frequency of the spurious component concerned.

FIG. 2. — Measuring arrangement for terminal spurious narrow-bandwidth radio-frequency components.

8.3.3 *Method of measurement at the audio, control or power terminals for frequencies below 30 MHz*

a) Connect the equipment as illustrated in figure 2, page 12, with the selective voltmeter connected to the radio-frequency output terminals (A) of the line stabilization network.

Note. — An example of a mains power line stabilization network suitable for use on the mains power line is given in appendix C. Examples of networks for use with audio lines and for battery-powered equipment are under consideration.

b) With the transmitter operating at the carrier power level measured in 8.2, adjust the selective voltmeter to the centre frequency of each spurious narrow-bandwidth radio-frequency component to be measured. Record the frequency and the voltage of each measured component along with the input impedance of the selective voltmeter.

8.3.4 *Presentation of results*

The values recorded in 8.3.2 shall be expressed either as absolute power or as a ratio, in decibels, relative to the carrier power, for each spurious narrow-bandwidth radio-frequency component that is measured.

The values recorded in 8.3.3, step *b)* shall be expressed in volts, specifying the test circuit used.

The carrier power level shall be recorded, as measured in 8.2.

8.4 *Spurious transmitter noise*

8.4.1 *General*

Spurious transmitter noise which falls within the bandwidth of any receiver may degrade the receiver performance. The methods of measurement provide for assessing the transmitter noise in terms of:

a) the attenuation required to avoid more than a specified degradation of receiver performance, or

b) the spectral power density, which may be used more generally.

Note. — This method of measurement may not be suitable for certain types of impulsive noise.

8.4.2 *Definition*

Spurious transmitter noise is the continuous spectrum of noise components present at the transmitter output terminals.

8.4.3 *Method of measurement*

a) Connect the equipment as illustrated in figure 3, page 14.

Note. — Recommended characteristics of the measuring equipment are described in appendix A.

b) With the transmitter not operating, apply a signal from the signal generator (7) with standard test modulation to port (b) of the matching or combining network (6).

c) Adjust the standard test receiver (8) and the signal generator (7) to operate on a frequency which is displaced from the transmitter operating frequency by Δf, e.g. = 40 kHz.

d) Adjust the signal level to a value that is 3 dB greater than reference sensitivity.

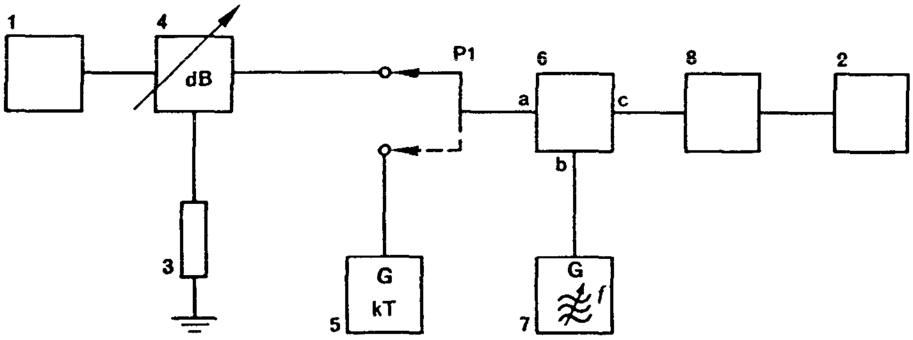
e) With the transmitter operating at the carrier power level measured in 8.2, adjust attenuator (4) to reduce the signal-to-noise ratio at the receiver output terminals to the standard value (12 dB SINAD). Record the values of attenuation of attenuator (4) and of the matching or combining network (b) between ports (a) and (c).

f) Record the value of the reference sensitivity of the test receiver.

g) The measurements should be repeated at other values of Δf above and below the transmitter carrier frequency.

In order to obtain the spectral power density of the transmitter noise at each of the Δf values referred to in step *g)*, proceed as follows:

h) With the transmitter not operating, change the connection at P1 from the attenuator (4) to the noise generator (5) and, with the radio-frequency signal generator (7) adjusted according to steps *b)* to *d)* above, apply a noise spectrum from the noise generator (5) at a level to reduce the signal-to-noise ratio at the receiver output terminal to the standard value, i.e. 12 dB. Record the value of the spectral power density *p*, expressed in dB (kT), at the output of the noise generator.



Legend
1 – transmitter under test
2 – distortion-factor meter
3 – test load
4 – coupler/attenuator device
5 – white noise generator (if used)
6 – matching or combining network
7 – radio-frequency signal generator
8 – standard test receiver

Note. – The measuring arrangement shall be capable of measuring noise to a level 10 dB lower than the noise of the transmitter.

FIG. 3. — Measuring arrangement for terminal spurious transmitter noise.

The spectral power density *N* of the transmitter noise at the radio frequency to which the receiver is tuned is equal to the value of *p* plus the attenuation of attenuator (4) recorded in step *e)*.

Note. – The expression "kT" sometimes appears in technical documents as "kTb", where "b" is equal to a bandwidth of 1 Hz.

i) The measurements should be repeated at other values of Δf above and below the transmitter carrier frequency.

8.4.4 *Presentation of results*

a) Required path attenuation between the transmitter output terminals and the receiver input terminals

Plot the values of total attenuation recorded in 8.4.3, steps *e)* and *g)*, on the linear ordinate of a graph with the values of Δf on the logarithmic abscissa.

Record the value of the reference sensitivity and/or the noise figure of the test receiver.

Note. — An affected receiver may have different characteristics from the test receiver used. This should be taken into account when interpreting the results.

b) Spectral power density of the transmitter noise

Plot the spectral power densities of *N* calculated in 8.4.3, step *h)* on the linear ordinate of a graph with the values of Δf on the logarithmic abscissa.

8.5 *Adjacent channel power for transmitters with accessible antenna terminals*

8.5.1 *Definition*

The adjacent channel power of transmitters operating in systems allocated on a channel basis is that part of the total power ouput of a transmitter which, under defined conditions of modulation, falls within a specified bandwidth centred on the centre frequency of either of the adjacent channels.

This power is measured by means of a power measuring receiver having its -6 dB response frequencies displaced from the transmitter carrier frequency by amounts derived from the channel spacing or by means of a spectrum analyzer. This measurement provides the ratio, expressed in decibels, of the carrier power to the adjacent channel power. For the purpose of this measurement, this ratio is called the "adjacent channel power ratio".

Note. — The following are several of the commonly used channel spacings and specified bandwidths:

Channel spacings (kHz)	*Specified bandwidths (kHz)*
30	16
25	16
20	16
20	14
15	8.5
12.5	8.5
10	8.5

8.5.2 *Method of measurement – Power measuring receiver*

a) Connect the equipment, as illustrated in figure 4, page 19, using a power measuring receiver of specified selectivity. See clause A7 of appendix A for the required characteristics of the power measuring receiver.

b) Operate the transmitter at the carrier power measured as described in 8.2.

c) Set the i.f. attenuator (4C) to a high value, for example 70 dB, then adjust the coupler/attenuator (3) to provide a signal level which is within the linear range of the power measuring receiver.

d) Adjust the frequency of the local oscillator (4A) to obtain a maximum reading on the r.m.s. meter (4D). Record this reading, and the attenuation of the i.f. attenuator, in decibels.

e) Increase the frequency of the local oscillator (4A) until the indication on the r.m.s. meter is reduced by 6 dB. Record the frequency of the local oscillator.

f) Increase the frequency of the local oscillator (4A) by an additional amount equal to the channel spacing minus one-half of the specified bandwidth.

Note. — The following are several of the commonly used channel spacings and specified bandwidths.

Channel spacings (kHz)	*Specified bandwidths (kHz)*	*Filter bandwidths (kHz)*	*Displacement of the reference point from the carrier frequency (kHz)*
25	16	16	17
20	16	16	12
20	14	14	13
12.5	8.5	8.5	8.25
10	8.5	8.5	5.75

g) Modulate the transmitter at 1 250 ± 2 Hz with a signal at a level which is 10 dB greater than the level that produces:

1) a modulation depth of 60% for AM transmitters, or

2) 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

h) Adjust the i.f. attenuator (4C) until the indication of the r.m.s. meter is approximately the same as that recorded in step *d)*. Record the reading of the r.m.s. meter and the attenuation of the i.f. attenuator, in decibels.

i) The adjacent channel power ratio, A, is the difference of the attenuator values, recorded in steps *d)* and *h)*, corrected for the difference in readings of the r.m.s. meter in those steps. Record this value.

j) Remove the modulation from the transmitter and set the i.f. attenuator to the value recorded in step *d)*.

k) Repeat steps *c)* through *i)*, but decrease the frequency of the local oscillator in steps *f)* and *g)*.

8.5.3 *Presentation of results*

a) Calculate and state the power, P(adjacent channel), in each of the adjacent channels from the ratios A recorded in 8.5.2, steps *i)* and *k)*, and the carrier power P(carrier) measured as described in 8.2:

$$P(\text{adjacent channel}) = P(\text{carrier}) \times 10^{-A/10} \text{ in watts}$$

b) Calculate and state the 6 dB bandwidth of the power measuring receiver. This is the difference between the two values of the local oscillator frequency recorded in 8.5.2, steps *e)* and *k)*.

8.5.4 *Methods of measurement – Spectrum analyzer*

There are two methods of measurement using a spectrum analyzer given here. The first method (see 8.5.5) allows the use of non-digital storage types of spectrum analyzers which will give a measurement accuracy of ±2 dB when a significant part of the adjacent channel power is contained in one or more spectral components rather than in the noise.

The second method of measurement (see 8.5.7) uses a digital storage spectrum analyzer and can be used for all cases when a detector correction factor F_n is applied, typically between 0 and 2.5 dB for a mixture of sinusoidal components and thermal noise. For this standard, F_n will be 1 dB (see clause A8 of appendix A for a method of measurement of the maximum adjacent channel power ratio of the digital storage spectrum analyzer to be used).

8.5.5 *Method of measurement – Non-digital storage spectrum analyzer*

a) Connect the equipment, as illustrated in figure 4, page 19, using a spectrum analyzer for item (4). Adjust the spectrum analyzer as follows:

- resolution and video filter bandwidth to the lowest possible setting, but not less than the specified bandwidth divided by 200 nor greater than the specified bandwidth divided by 40, and record this as R;
- total swept bandwidth to the lowest possible setting which is equal to or greater than the specified bandwidth and record this as B;
- the sweep time to greater than $3B/R^2$.

Adjust the coupler/attenuator (3) to a value which is compatible with the input characteristics of the spectrum analyzer.

b) Operate the transmitter unmodulated at the carrier power measured as described in 8.2.

c) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the carrier frequency of the transmitter.

d) Adjust the coupler/attenuator (3) and the sensitivity of the spectrum analyzer to values suitable to provide a displayed figure on the screen which is in the linear range of the spectrum analyzer. Record the value P_c of the transmitted carrier in dBm.

e) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the centre frequency of the upper adjacent channel.

f) Modulate the transmitter at 1 250 ± 2 Hz with a signal level which is 10 dB greater than the level that produces:

- 60% modulation depth for AM transmitters, or
- 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

g) Within the specified bandwidth determine whether the value of the largest component exceeds the highest noise power level by at least

$$10 \lg (B/R) + 3 \text{ dB}$$

If not, the method of measurement in 8.5.7 should be used.

If so, record the values of the components $A_1, A_2, \ldots A_n$, within the specified bandwidth in dBm. Calculate and record the indicated adjacent channel power:

$$P_a = 10 \lg \sum_{i=1}^{i=n} 10^{A_i/10} \quad \text{dBm}$$

where n is the number of samples

h) Using the lower adjacent channel, repeat steps *e)* through *g)*.

8.5.6 *Presentation of results*

a) Calculate the ratio PR for the upper adjacent channel using the following relationship

$$PR = P_c - P_a \quad \text{dB}$$

where:

P_c is the value recorded in 8.5.5, step *d)*

P_a is the value recorded in 8.5.5, step *g)*, for the upper adjacent channel

b) Repeat step *a)* for the lower adjacent channel.

c) Record the lower value of PR calculated in steps *a)* and *b)* as the adjacent channel ratio *(ACPR)*.

d) Calculate the power (adjacent channel) P_{adj} using the following relationship:

$$P_{adj} = P \times 10^{-ACPR/10} \quad \text{W}$$

where:

P is the carrier power measured in 8.2.2 in watts

$ACPR$ is the value recorded in step *c)*

Record this value as the adjacent channel power.

e) Record the channel spacing, the specified bandwidth and the carrier power.

8.5.7 *Method of measurement – Digital storage spectrum analyzer*

a) Connect the equipment as illustrated in figure 4, page 19, using a digital storage spectrum analyzer for item (4). Adjust the spectrum analyzer as follows:

- resolution and video filter bandwidth to the lowest possible setting, but not less than the specified bandwidth divided by 200 nor greater than the specified bandwidth divided by 40, and record this as *R*;
- total swept bandwidth to the lowest possible setting which is equal to or greater than the specified bandwidth and record this as *B*;
- the sweep time to greater than $3B/R^2$.

Adjust the coupler/attenuator (3) to a value which is compatible with the input characteristics of the spectrum analyzer.

b) Operate the transmitter unmodulated at the carrier power measured as described in 8.2.

c) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the carrier frequency of the transmitter.

d) Adjust the coupler/attenuator (3) and the sensitivity of the spectrum analyzer to values suitable to provide a displayed figure on the screen which is in the linear range of the spectrum analyzer.

Activate the digital storage spectrum analyzer to record the values C_i in dBm for at least 200 samples uniformly distributed throughout the specified bandwidth. Calculate and record the indicated carrier power:

$$P_c = 10 \lg \sum_{i=1}^{i=n} 10^{C_i/10} \quad \text{dBm}$$

where *n* is the number of samples

e) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the centre frequency of the upper adjacent channel.

f) Modulate the transmitter at 1 250 ± 2 Hz with a signal level which is 10 dB greater than the level that produces:

- 60% modulation depth for AM transmitters, or
- 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

g) Activate the digital storage spectrum analyzer to record the values A_i in dBm for the same number of samples used in step *d)* uniformly distributed throughout the specified bandwidth. Calculate and record the indicated adjacent channel power:

$$P_a = 10 \lg \sum_{i=1}^{i=n} 10^{A_i/10} \quad \text{dBm}$$

where *n* is the number of samples

h) Using the lower adjacent channel repeat steps *e)* through *g)*.

8.5.8 *Presentation of results*

a) Calculate the ratio *PR* for the upper adjacent channel using the following relationship:

$$PR = P_c - [P_a + 1] \quad \text{dB}$$

where:

P_c is the value recorded in 8.5.7, step *d)*

P_a is the value recorded in 8.5.7, step *g)*, for the upper adjacent channel

Note. — For an explanation of the 1 dB in the equation, see 8.5.4.

b) Repeat step *a)* for the lower adjacent channel

c) Record the lower value of *PR* calculated in steps *a)* and *b)* as the adjacent channel power ratio *(ACPR)*.

d) Calculate the power (adjacent channel) P_{adj} using the following relationship:

$$P_{adj} = P \times 10^{-ACPR/10}\ \mathrm{W}$$

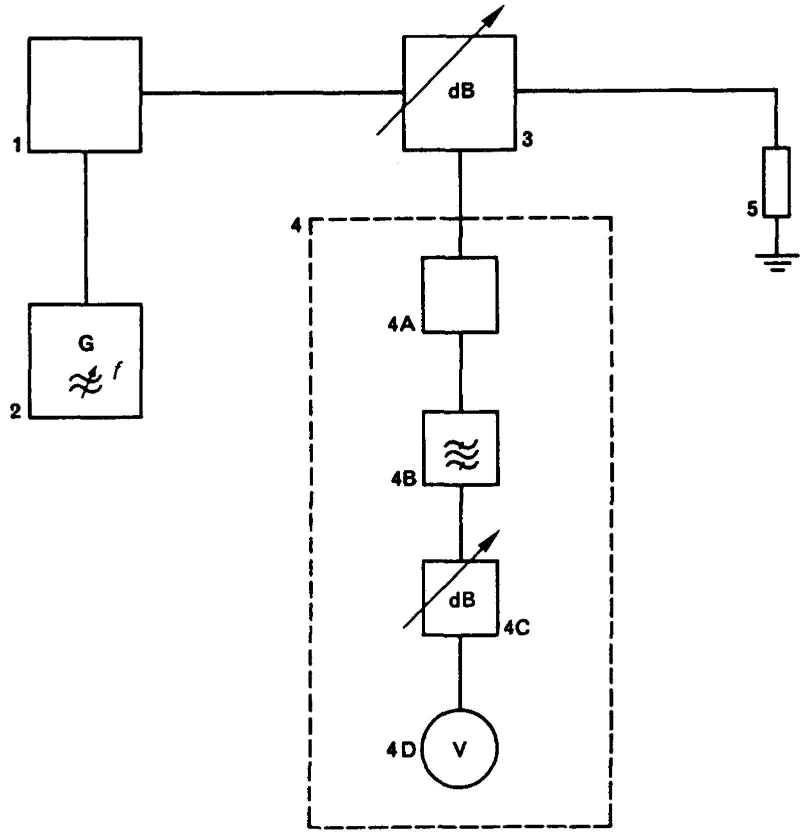
where:

P is the carrier power measured in 8.2.2 in watts

$ACPR$ is the value recorded in step *c)*

Record this value as the adjacent channel power.

e) Record the channel spacing, the specified bandwidth and the carrier power.



Legend

1 = transmitter under test
2 = audio-frequency generator
3 = coupler/attenuator device (may be incorporated in the test load)
4 = power measuring receiver
    4A = mixer and local oscillator
    4B = channel band-pass filter
    4C = i.f. attenuator (0 to 80 dB)
    4D = r.m.s. meter (may be preceded by an i.f. amplifier)
5 = test load

FIG. 4. — Measuring arrangement for terminal adjacent channel power.

9. Radiated radio-frequency power

These measurements are usually made only on transmitters having integral antennas.

9.1 *General*

The radiated radio-frequency power output of a transmitter may contain:

- a carrier component (see 8.2);
- modulation components determining transmission quality (see clauses 12, 13 and 14);
- other modulation components (e.g. components contributing to the adjacent channel power) (see 8.5);
- spurious narrow-bandwidth components (see 9.3);
- noise, both inside the band (see clause 16) and outside the band, where it is called spurious transmitter noise (see 9.4), and
- inter-transmitter intermodulation products (see clause 11).

The measured levels may be due to the radiation from the antenna, audio lines, control lines, power mains or from the cabinet.

These measurements generally require the use of a test site. Guides for the construction of such test sites are given in appendices of this standard.

9.2 *Average radiated power for transmitters with integral antennas*

9.2.1 *Definition*

The average of the radiated powers in eight directions distributed at 45° angles in the horizontal plane.

9.2.2 *Method of measurement*

a) Choose the test site suitable for the frequency and use of the transmitter from those described in the appendices.

The 30 m test site (appendix B) should be the reference for transmitters operating in the frequency range 25 MHz to 1 000 MHz. Any other test site described in some appendices of this standard may also be used, provided account is taken of the limitations attached to the use of the test site that is chosen.

b) Connect the equipment under test as illustrated in the chosen appendix.

c) Adjust the length of the measuring antenna (if adjustable) for the frequency of the transmitter.

d) Position the measuring antenna within the specified elevation range for vertical polarization.

e) Activate the transmitter.

f) Tune the selective measuring device, e.g. spectrum analyzer, to the transmitter operating frequency.

g) Rotate the equipment under test to obtain the maximum indication on the selective measuring device.

h) Raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device. Note the value of the indication and the setting of the attenuator.

Note. — The maximum may be a lower value than the value obtainable at heights outside the specified limits.

i) Rotate the equipment under test 45° clockwise and note the new value.

j) Repeat step *i)* until values have been obtained for eight azimuth positions.

k) Replace the equipment under test with the auxiliary antenna connected to the radio-frequency generator, in accordance with the instructions in the chosen appendix.

l) Raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device.

m) Adjust the output of the r.f. signal generator, and where necessary the attenuator, to obtain the level recorded in step *h)*. Record the output level corrected for the attenuator value.

9.2.3 *Presentation of results*

Calculate the maximum effective radiated power, P_{max}, of the equipment under test from the reading taken in 9.2.2, step *h)*, taking into account the attenuator setting, the auxiliary antenna gain, and the cable loss between the generator and the auxiliary antenna.

Notes 1. – The measured power of an unmodulated AM transmitter should be multiplied by 1.18 to take into account the additional power corresponding to a modulation depth of 60%.

The radiated power is the average of the eight values calculated above.

2. – On request, the maximum radiated power, which is the maximum value determined above, can be stated.

9.3 *Spurious narrow-bandwidth components*

9.3.1 *Definition*

Spurious narrow-bandwidth radio-frequency components include harmonic and non-harmonic components and parasitic components that are usually characterized by a signal having a dominant component at a discrete frequency or in a narrow band of frequencies.

Components in the immediate vicinity of the necessary band which are a result of the modulation process for the transmission of information are excluded.

9.3.2 *Method of measurement* (see figure 5, page 23)

Note. — The value of the average radiated power determined in 9.2 is required for this measurement. It should be measured on the same test site that is chosen in the following step *a)*.

a) Choose the test site, suitable for the range of frequencies applicable and power levels to be measured, from those described in the test site appendices.

b) Connect the equipment as illustrated in the chosen appendix. When a particular step in the method of measurement requires an antenna to be raised and lowered to find a maximum indication, use the height limits in the chosen test site description.

c) Activate the equipment under test (unmodulated).

Note. — Radio regulations establish limits for spurious components of a modulated emission. However, at this time no practical method has been developed for measuring spurious components of the transmitter while being modulated.

d) Identify the frequencies of the significant spectral components by using the selective measuring device, e.g. spectrum analyzer. If necessary, closely couple it to the equipment under test.

e) Adjust the measuring antenna (if adjustable) to the correct length for the frequency of each significant spectral component to be considered.

f) Tune the selective measuring device to a significant spectral component.

g) Orient the measuring antenna so that it is vertically polarized.

h) Rotate the equipment under test to obtain the maximum indication on the selective measuring device.

i) When required by the test site description, raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device.

Note. — The maximum may be a lower value than the value obtainable at heights outside the specified limits.

j) Repeat steps *h)* and *i)* until no further increase occurs. Record the corresponding maximum indication and the frequency of the component.

k) Orient the measuring antenna so that it is horizontally polarized and repeat steps *h)*, *i)* and *j)*.

l) Repeat steps *e)* to *k)* for all significant spectral components until the levels have been measured for all significant spectral components.

m) Replace the equipment under test with the auxiliary antenna.

n) Select one of the significant spectral components measured in step *j)* and adjust the frequency of the radio-frequency generator to its frequency.

o) Adjust the length of the auxiliary antenna (if adjustable) to the frequency of the significant spectral component.

p) Adjust the length of the measuring antenna (if adjustable) to the frequency of the significant spectral component.

q) Tune the selective measuring device to the frequency of the significant spectral component.

r) Position the auxiliary and measuring antennas for vertical polarization.

s) Adjust the output level of the radio-frequency signal generator to provide an indication on the selective measuring device.

t) Raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device.

u) Readjust the output level of the radio-frequency signal generator to obtain the same value of indication as noted in step *j)*. Note the output level of the radio-frequency signal generator and its frequency.

v) Repeat steps *s)* to *u)* with the auxiliary and measuring antennas horizontally polarized.

w) Repeat steps *n)* to *v)* for the remaining significant spectral components measured in step *j)*.

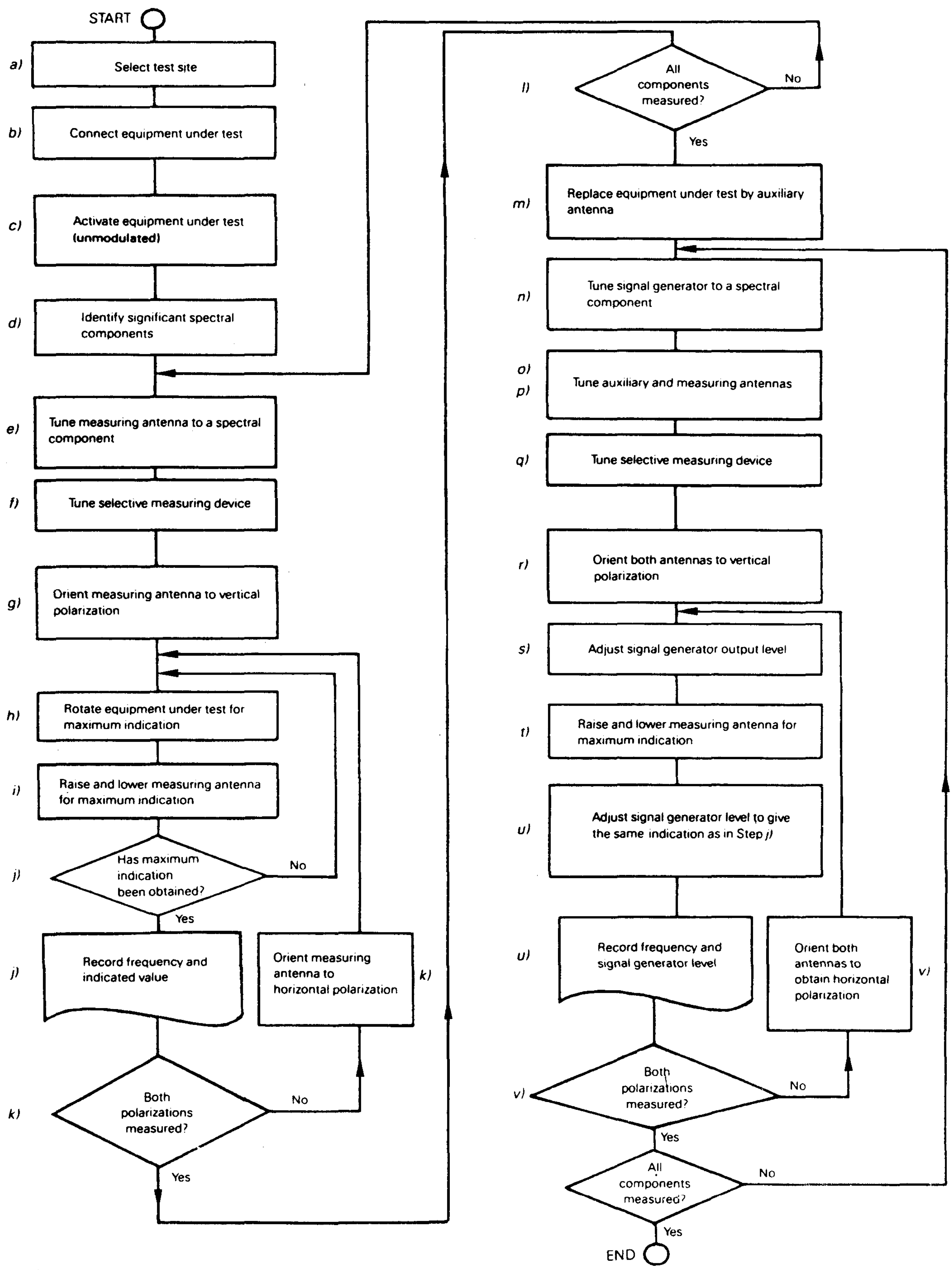

START
a) Select test site
b) Connect equipment under test
c) Activate equipment under test (unmodulated)
d) Identify significant spectral components
e) Tune measuring antenna to a spectral component
f) Tune selective measuring device
g) Orient measuring antenna to vertical polarization
h) Rotate equipment under test for maximum indication
i) Raise and lower measuring antenna for maximum indication
j) Has maximum indication been obtained?
No
Yes
j) Record frequency and indicated value
k) Orient measuring antenna to horizontal polarization
k) Both polarizations measured?
No
Yes
l) All components measured?
No
Yes
m) Replace equipment under test by auxiliary antenna
n) Tune signal generator to a spectral component
o) p) Tune auxiliary and measuring antennas
q) Tune selective measuring device
r) Orient both antennas to vertical polarization
s) Adjust signal generator output level
t) Raise and lower measuring antenna for maximum indication
u) Adjust signal generator level to give the same indication as in Step j)
u) Record frequency and signal generator level
v) Orient both antennas to obtain horizontal polarization
v) Both polarizations measured?
No
Yes
All components measured?
No
Yes
END

FIG. 5. — Flow chart.

9.3.3 *Presentation of results*

Calculate the power available to the auxiliary antenna from the values noted in 9.3.2, step *u)*, taking into account the different settings of the attenuator, the gain of the auxiliary antenna and the cable loss between the radio-frequency signal generator and the auxiliary antenna.

The powers thus calculated characterize the spurious narrow-bandwidth components of the transmitter under test. Each should be expressed either as an absolute value or in decibels in relation to the average radiated power as described in 9.2.

Record these powers and frequencies of the corresponding spurious narrow-bandwidth components in a table.

9.4 *Spurious transmitter noise*

9.4.1 *General*

Spurious transmitter noise which falls within the bandwith of any receiver may degrade the receiver performance. The methods of measurement provide for assessing the transmitter noise in terms of:

a) the attenuation required to avoid more than a specified degradation of receiver performance, or

b) the spectral power density, which may be used more generally.

9.4.2 *Definition*

Spurious transmitter noise is the continuous spectrum of noise components radiated by the transmitter.

9.4.3 *Method of measurement*

a) Connect the equipment as illustrated in figure 6, page 25.

Note. — Recommended characteristics of the standard test receiver are described in appendix A.

b) Place the transmitter near the test antenna or in the position specified for any other radiation-coupling device.

c) Operate the transmitter at the output power level measured in 9.2 modulated with standard test modulation.

d) Adjust the receiver (8) to receive the transmitter carrier frequency and reduce the radio-frequency signal generator (7) output to minimum.

e) Adjust attenuator (4) to produce the standard signal-to-noise ratio, i.e. 12 dB at the receiver output terminals. Record the value of attenuation of attenuator (4).

f) With the transmitter not operating, adjust the frequency of the radio-frequency signal generator to the frequency of the test receiver and adjust the signal level to produce the standard signal-to-noise ratio (12 dB) at the receiver output terminals. Measure and record the power at port (b) of the matching or combining network (6). Verify that the coupling loss from ports (a) to (c) is the same as from ports (b) to (c).

g) Calculate the coupling loss from the transmitter to port (a). It is the value of the ratio, in decibels, of the transmitter effective radiated power to the power measured at port (b). (Both powers are expressed in dBW.)

h) Calculate the coupling loss of the coupling device (3). It is the value calculated in step *g)* minus the attenuation of attenuator (4), recorded in step *e)*.

i) Adjust the standard test receiver (8) and the radio-frequency signal generator (7) to operate on a frequency which is displaced from the transmitter operating frequency by Δf, e.g. 40 kHz.

j) Adjust the input signal to a level that is 3 dB greater than reference sensitivity.

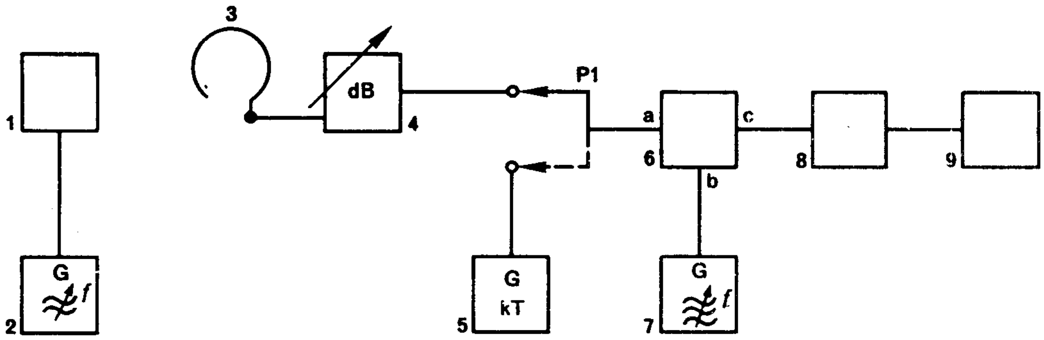
k) With the unmodulated transmitter operating at the carrier power level measured in 9.2, adjust attenuator (4) to reduce the signal-to-noise ratio at the receiver output terminals to 12 dB. Record the values of attenuation of attenuator (4) and of the matching or combining network between ports (a) and (c).

l) Record the value of the reference sensitivity of the test receiver.

m) The measurements should be repeated at other values of Δf above and below the transmitter carrier frequency.

In order to obtain the spectral power density of the transmitter noise at each of the values of Δf referred to in step *m)*, proceed as follows:

n) With the transmitter not operating, change the connection at P1 from the attenuator (4) to the noise generator (5) and with the radio-frequency signal generator (7) adjusted according to steps *i)* and *j)* above, apply a noise spectrum from the noise generator (5) at a level to reduce the signal-to-noise ratio at the receiver output terminal to the standard value, i.e. 12 dB. Record the value of the spectral power density *p*, expressed in dB (kT), at the output of the noise generator.



Legend
1 – transmitter under test
2 – audio-frequency generator
3 – calibrated loop antenna
4 – coupling device, e.g. calibrated loop antenna
5 – white noise generator (if used)
6 – matching or combining network
7 – radio-frequency signal generator
8 – standard test receiver
9 – distortion-factor meter

Note. — The measuring arrangement shall be capable of measuring noise to a level 10 dB lower than the noise of the transmitter.

FIG. 6. — Measuring arrangement for radiated spurious transmitter noise.

The spectral power density *N* of the transmitter noise at the radio frequency to which the receiver is tuned is equal to the value of *p* plus the attenuation of attenuator (4) recorded in step *k)*, plus the coupling loss recorded in step *h)*.

9.4.4 *Presentation of results*

a) Required path attenuation between the transmitter output and the receiver input terminals

Add the attenuations recorded in 9.4.3, steps *h)* and *k)*, and plot this value on the linear ordinate of a graph with the values of Δf on the logarithmic abscissa.

Record the value of the reference sensitivity and/or the noise figure of the test receiver.

Note. — An affected receiver may have different characteristics from the test receiver used. This should be taken into account when interpreting the results.

b) Spectral power density of the transmitter noise

Plot the spectral power densities in values on N calculated in 9.4.3, step *n)*, on the linear ordinate of a graph with the values of Δf on the logarithmic abscissa.

9.5 *Radiated adjacent channel power for transmitters with integral antennas*

9.5.1 *Definition*

The adjacent channel power of transmitters operating in systems allocated on a channel basis is that part of the total power output of a transmitter, under defined conditions of modulation, which falls within a specified bandwidth centred on the centre frequency of either of the adjacent channels.

This power is measured by means of a power measuring receiver having its −6 dB response frequencies displaced from the transmitter carrier frequency by amounts derived from the channel spacing or by means of a spectrum analyzer. This measurement provides the ratio, expressed in decibels, of the carrier power to the adjacent channel power. For the purpose of this measurement this ratio is called the "adjacent channel power ratio".

Note. — The following are several of the commonly used channel spacings and specified bandwidths.

Channel spacings (kHz)	*Specified bandwidths (kHz)*
30	16
25	16
20	16
20	14
15	8.5
12.5	8.5
10	8.5

9.5.2 *Method of measurement – Power measuring receiver*

a) Connect the equipment, as illustrated in figure 7, page 31, using a power measuring receiver of specified selectivity. See clause A7 of appendix A for the required characteristics of the power measuring receiver.

b) Place the transmitter near the test antenna or in the position specified for any other radiation-coupling device.

c) Operate the transmitter at the effective radiated power level measured as described in 9.2.

d) Set the i.f. attenuator (4C) to a high value, for example 70 dB, then adjust the coupler/attenuator (3) to provide a signal level which is within the linear range of the power measuring receiver.

e) Adjust the frequency of the local oscillator (4A) to obtain a maximum reading on the r.m.s. meter (4D). Record this reading, and the attenuation of the i.f. attenuator, in decibels.

f) Increase the frequency of the local oscillator (4A) until the indication on the r.m.s. meter is reduced by 6 dB. Record the frequency of the local oscillator.

g) Increase the frequency of the local oscillator (4A) by an additional amount equal to the channel spacing minus one-half of the specified bandwidth.

Note. — The following are several of the commonly used channel spacings and specified bandwidths.

Channel spacings (kHz)	*Specified bandwidths (kHz)*	*Filter bandwidths (kHz)*	*Displacement of the reference point from the carrier frequency (kHz)*
25	16	16	17
20	16	16	12
20	14	14	13
12.5	8.5	8.5	8.25
10	8.5	8.5	5.75

h) Modulate the transmitter at 1 250 ± 2 Hz with a signal at a level which is 10 dB greater than the level that produces:

1) a modulation depth of 60% for AM transmitters, or
2) 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

i) Adjust the i.f. attenuator (4C) until the indication of the r.m.s. meter is approximately the same as that recorded in step *d)*. Record the reading of the r.m.s. meter and the attenuation of the i.f. attenuator, in decibels.

j) The adjacent channel power ratio, A, is the difference of the attenuator values recorded in steps *e)* and *i)*, corrected for the difference in readings of the r.m.s. meter recorded in those steps. Record this value.

k) Remove the modulation from the transmitter and set the i.f. attenuator (4C) to the value recorded in step *e)*.

l) Repeat steps *d)* through *j)* but decrease the frequency of the local oscillator in steps *f)* and *g)*.

9.5.3 *Presentation of results*

a) Calculate and state the power, P(adjacent channel), in each of the adjacent channels from the ratios A recorded in 9.5.2, steps *j)* and *l)*, and the effective radiated power, P(effective radiated) measured in 9.2, from the formula:

$$P(\text{adjacent channel}) = P(\text{effective radiated}) \times 10^{-A/10} \text{ in watts}$$

b) Calculate and state the 6 dB bandwidth of the power measuring receiver. This is the difference between the two values of the local oscillator frequency recorded in steps *f)* and *l)*.

9.5.4 *Methods of measurement – Spectrum analyzer*

There are two methods of measurement using a spectrum analyzer given here. The first method (see 9.5.5) allows the use of non-digital storage types of spectrum analyzers which will give a measurement accuracy of ± 2 dB when a significant part of the adjacent channel power is contained in one or more spectral components rather than in the noise.

The second method of measurement (see 9.5.7) uses a digital storage spectrum analyzer and can be used for all cases when a detector correction factor F_n is applied, typically between 0 and 2.5 dB for a mixture of sinusoidal components and thermal noise. For this standard, F_n will be 1 dB (see clause A8 of appendix A for a method of measurement of the maximum adjacent channel power ratio of the digital storage spectrum analyzer to be used).

9.5.5 *Method of measurement – Non-digital storage spectrum analyzer*

a) Connect the equipment as illustrated in figure 7, page 31, using a spectrum analyzer for item (4). Adjust the spectrum analyzer as follows:

- resolution and video filter bandwidth to the lowest possible setting, but not less than the specified bandwith divided by 200 nor greater than the specified bandwidth divided by 40, and record this as R;
- total swept bandwidth to the lowest possible setting which is equal to or greater than the specified bandwidth and record this as B;
- the sweep time to greater than $3B/R^2$.

Adjust the coupler/attenuator (3) to a value which is compatible with the input characteristics of the spectrum analyzer.

b) Operate the transmitter unmodulated at the carrier power measured as described in 8.2.

c) Place the transmitter near the test antenna or in the position specified for any other radio-frequency coupling device.

d) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the carrier frequency of the transmitter.

e) Adjust the coupler/attenuator (3) and the sensitivity of the spectrum analyzer to values suitable to provide a displayed figure on the screen which is in the linear range of the spectrum analyzer. Record the value P_c of the transmitted carrier in dBm.

f) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the centre frequency of the upper adjacent channel.

g) Modulate the transmitter at 1 250 ± 2 Hz with a signal level which is 10 dB greater than the level that produces:

- 60% modulation depth for AM transmitters, or
- 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

h) Within the specified bandwith determine whether the amplitude of the largest component exceeds the highest noise power level by at least

$$10\lg(B/R) + 3\ \text{dB}$$

If not, the method of measurement in 9.5.7 should be used.

If so, record the values of the components $A_1, A_2, \ldots, A_n$, within the specified bandwith, in dBm. Calculate and record the indicated adjacent channel power:

$$P_a = 10\lg \sum_{i=1}^{i=n} 10^{A_i/10} \quad \text{dBm}$$

where n is the number of samples

i) Using the lower adjacent channel, repeat steps *f)* through *h)*.

).5.6 *Presentation of results*

a) Calculate the ratio PR for the upper adjacent channel using the following relationship:

$$PR = P_c - P_a \quad \text{dB}$$

where:

P_c is the value recorded in 9.5.5, step *e)*

P_a is the value recorded in 9.5.5, step *h)*, for the upper adjacent channel

b) Repeat step *a)* for the lower adjacent channel.

c) Record the lower value of *PR* calculated in steps *a)* and *b)* as the adjacent channel power ratio *(ACPR)*.

d) Calculate the power (adjacent channel) P_{adj} using the following relationship:

$$P_{adj} = P \times 10^{-ACPR/10}\ \mathrm{W}$$

where:

P is the effective radiated power measured in 9.2.2 in watts

$ACPR$ is the value recorded in step *c)*

Record this value as the adjacent channel power.

e) Record the channel spacing, the specified bandwidth and the effective radiated power.

9.5.7 *Method of measurement – Digital storage spectrum analyzer*

a) Connect the equipment as illustrated in figure 6, page 25, using a digital storage spectrum analyzer for item (4). Adjust the digital storage spectrum analyzer as follows:

- resolution and video filter bandwidth to the lowest possible setting, but not less than the specified bandwidth divided by 200 nor greater than the specified bandwidth divided by 40 and record this as R;
- total swept bandwidth to the lowest possible setting which is equal to or greater than the specified bandwidth and record this as B;
- the sweep time to greater than $3\,B/R^2$.

Adjust the coupler/attenuator (3) to a value which is compatible with the input characteristics of the spectrum analyzer.

b) Operate the transmitter unmodulated at the carrier power measured as described in 8.2.

c) Place the transmitter near the test antenna or in the position specified for any other radio-frequency coupling device.

d) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the carrier frequency of the transmitter.

e) Adjust the coupler attenuator (3) and the sensitivity of the spectrum analyzer to values suitable to provide a displayed figure on the screen which is in the linear range of the spectrum analyzer.

Activate the digital storage spectrum analyzer to record the values C_i in dBm for at least 200 samples uniformly distributed throughout the specified bandwidth. Calculate and record the indicated carrier power:

$$P_c = 10\lg \sum_{i=1}^{i=n} 10^{C_i/10}\ \ \mathrm{dBm}$$

where n is the number of samples.

f) Adjust the spectrum analyzer so that the centre of the displayed figure coincides with the centre frequency of the upper adjacent channel.

g) Modulate the transmitter at 1 250 ± 2 Hz with a signal level which is 10 dB greater than the level that produces:

- 60% modulation depth for AM transmitters, or
- 60% of maximum permissible frequency (or phase) deviation for FM transmitters.

For equipment without modulation limiters which are intended to operate at a fixed input level, the measurement should be made using the input signal level specified by the manufacturer.

h) Activate the digital storage spectrum analyzer to record the values A_i in dBm for the same number of samples used in step *d)* uniformly distributed throughout the specified bandwidth. Calculate and record the indicated adjacent channel power:

$$P_a = 10 \lg \sum_{i=1}^{i=n} 10^{A_i/10} \quad \text{dBm}$$

where n is the number of samples

i) Using the lower adjacent channel, repeat steps *f)* through *h)*.

9.5.8 *Presentation of results*

a) Calculate the ratio PR for the upper adjacent channel using the following relationship:

$$PR = P_c - [P_a + 1] \quad \text{dB}$$

where:

P_c is the value recorded in 9.5.7, step *e)*

P_a is the value recorded in 9.5.7, step *h)*, for the upper adjacent channel

Note. — For an explanation of the 1 dB in the equation, see 9.5.4.

b) Repeat step *a)* for the lower adjacent channel.

c) Record the lower value of PR calculated in steps *a)* and *b)* as the adjacent channel power ratio *(ACPR)*.

d) Calculate the power (adjacent channel) P_{adj} using the following relationship:

$$P_{adj} = P \times 10^{-ACPR/10} \quad \text{W}$$

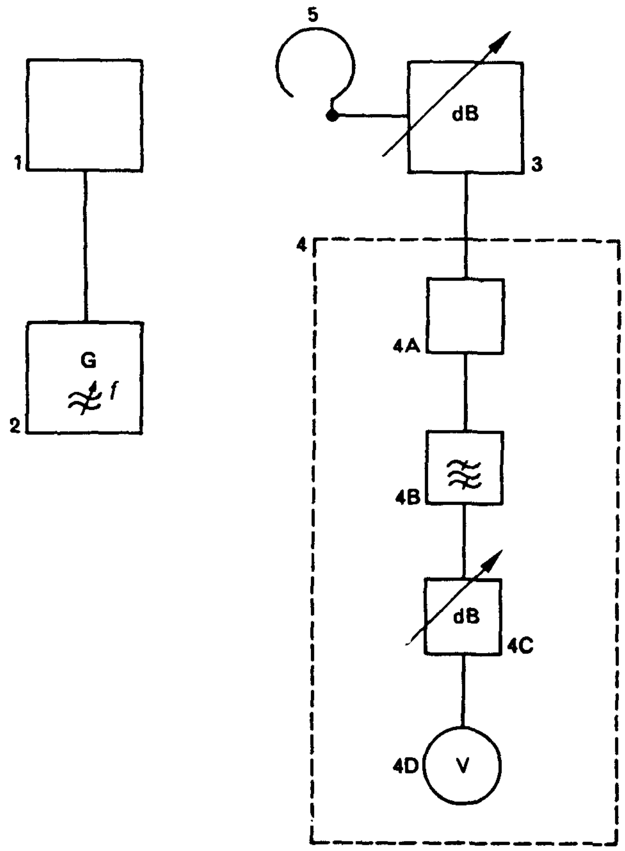
where:

P is the effective radiated power measured in 9.2.2 in watts

$ACPR$ is the value recorded in step *c)*

Record this value as the adjacent channel power.

e) Record the channel spacing, the specified bandwidth and the effective radiated power.



Legend
1 - transmitter under test
2 - audio-frequency generator
3 - coupler/attenuator device
4 - power measuring receiver
  4A - mixer and local oscillator
  4B - channel band-pass filter
  4C - i.f. attenuator (0 to 80 dB)
  4D - r.m.s. meter (may be preceded by an i.f. amplifier)
5 - calibrated loop antenna

FIG. 7. — Measuring arrangement for radiated adjacent channel power.

9.6 *Cabinet radiation*

9.6.1 *Definition and methods of measurement of cabinet radiation*

Methods of measurement of cabinet radiation of small and medium-sized transmitters are given in IEC 244-6. These methods of measurement are not applicable to transmitters with integral antennas.

Note. — IEC 244-6 describes two different methods, one for measurements at a distance of 3 m (in accordance with CISPR 13), and the other for measurements at a distance of 30 m, both being appropriate for frequencies between about 27 MHz and 1 000 MHz. A separate method, also suitable for frequencies above 1 GHz, is under consideration.

10. Input power and overall efficiency

10.1 *Input power*

10.1.1 *Definition*

The input power is the power delivered to the transmitter under specified conditions of operation and modulation, including the power absorbed by ancillary equipment required for normal operation.

10.1.2 *Method of measurement*

The input power for frequency or phase modulated equipment shall be measured without modulation.

For amplitude-modulated equipment, the input power shall be measured at specified amplitude deviation(s).

10.2 *Overall efficiency*

10.2.1 *Definition*

The overall efficiency is the ratio of the carrier power to the input power. It is usually expressed as a percentage.

Note. — For amplitude modulation, the amplitude deviation shall be specified.

11. Inter-transmitter intermodulation

11.1 *Definition*

Intermodulation between transmitters is the process by which intermodulation products are generated in a transmitter's output circuits due to the presence of an unwanted signal from another transmitter.

For the purpose of this standard, inter-transmitter intermodulation is expressed in terms of the ratio, in decibels, of the value specified for the interfering power which is incident upon the output of the disturbed transmitter to the power of the third-order intermodulation product.

Note. — This ratio is sometimes known as the "transmitter intermodulation conversion loss".

11.2 *Method of measurement*

a) Connect the equipment as shown in figure 8, page 33.

Note. — The impedance of all components in the measuring arrangement (with the possible exception of the output impedance of the transmitter under test) shall be the same as the characteristic impedance of the measuring arrangement transmission line.

The directional couplers shall be used to measure the incident and the reflected powers, and to make certain that there is not a gross mismatch between the test load and the measuring arrangement.

b) Operate the transmitter without modulation at rated power output and adjust the selective voltmeter (3) for maximum indication at the operating frequency of the transmitter. Record the carrier level with switch (4) in position A.

c) Adjust the frequency of the radio-frequency test signal source (9) to a frequency 100 kHz above the operating frequency of the transmitter.

d) Change the switch (4) to position B. Adjust the selective voltmeter for maximum reading at the frequency of the radio-frequency test signal source (9) and adjust the test signal level to produce a value 30 dB below the level recorded in step *b)*.

Note. — In some cases it will be difficult in step *d)* to generate a level 30 dB below that recorded in step *b)*. Since results are not appreciably affected by the test signal leve. he measurement can be performed at a lower level, for example 40 dB below that recorded in step *b)*. The exact level shall be stated in the test report.

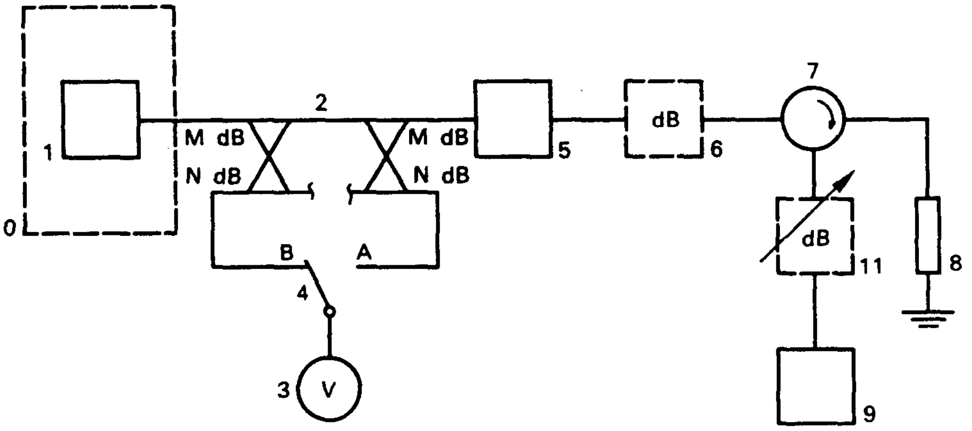
e) With the switch (4) in position A and the transmitter operating at rated power, adjust the selective voltmeter for maximum reading at the frequency of the third-order intermodulation product which is 100 kHz below the transmitter operating frequency.

f) Adjust the line stretcher (5) until the maximum level of the intermodulation product is obtained.

g) Repeat step *d)* and record the level of the signal from the radio-frequency test signal source.

h) Repeat step *e)* and record the level of the intermodulation product.

i) Change the switch (4) to position B and note the reading of the selective voltmeter. A level less than 10 dB lower than that measured in step *h)* indicates a source of intermodulation other than the transmitter under test, for example the radio-frequency test signal source (9) or the circulator (7). This shall be eliminated and step *h)* must then be repeated.



1 – transmitter under test
2 – two calibrated directional couplers (see notes 1 and 2)
3 – selective voltmeter
4 – switch
5 – line stretcher (see note 3)
6 – attenuator (if needed)
7 – circulator
8 – test load
9 – radio-frequency test signal source
10 – Faraday cage (if needed)
11 – attenuator (if needed)

Notes 1. – M dB is the coupling loss, typically 20 dB, and N dB is the directivity, typically 40 dB.

2. – A dual directional coupler can be used in lieu of the two directional couplers. Alternatively, it is possible to use a single directional coupler rotated to measure power from either direction, thereby making the switch (4) unnecessary.

3. – A line stretcher is used to maximize the intermodulation distortion.

FIG. 8. — Inter-transmitter intermodulation measuring arrangement.

j) The ratio, in decibels, of the level of the unwanted signal measured in step *g)* to the level of the intermodulation product measured in step *h)* is the inter-transmitter intermodulation.

Note. – The method of measurement can be used for other frequency spacings and levels of the radio-frequency test signal source (9). The selective voltmeter (3) shall have a selectivity sufficiently high so as not to be influenced by the carrier level when measuring the intermodulation product.

12. Modulation characteristic

12.1 *Definition*

The modulation characteristic is the change of the transmitter output-signal deviation as a function of the modulating frequency.

12.2 *Method of measurement for amplitude or frequency modulation*

a) Connect the equipment as illustrated in figure 9, page 35.

b) Set the audio-frequency generator (2) to 1 000 Hz and adjust its output level to obtain 30% of the maximum permissible frequency (or phase) deviation, or a modulation depth of 30%.

c) While maintaining the output level of the generator (2) established in step *b)*, vary the frequency over the specified range and record the deviation at each frequency.

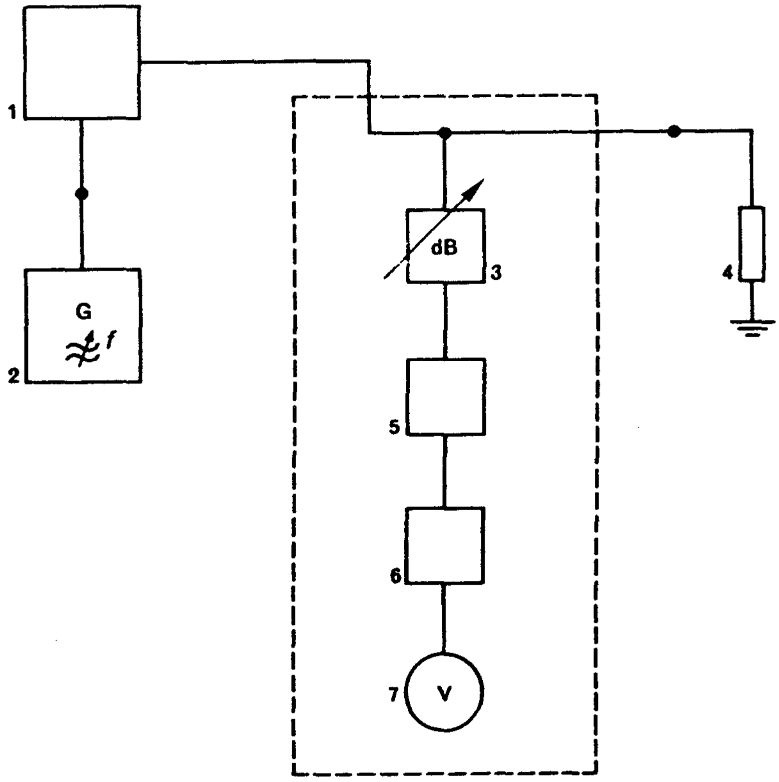
12.3 *Method of measurement for phase modulation*

a) Connect the equipment as illustrated in figure 9.

b) Set the frequency of the generator (2) to 1 000 Hz and adjust its output level to obtain 30% of the maximum permissible frequency (or phase) deviation.

c) While maintaining the output level of the generator (2) established in step *b)*, vary the frequency over the specified range below 1 000 Hz and record the deviation at each frequency.

d) While maintaining the deviation established in step *b)*, vary the audio-frequency over the specific range above 1 000 Hz and record the output level of the generator at each frequency. Calculate the deviation for the generator (2) level established in step *b)*.



Legend

1 = transmitter under test	5 = modulation monitor
2 = audio-frequency generator	6 = de-emphasis network and band-limiting filter
3 = coupler/attenuator	7 = distortion factor meter
4 = test load	

Note. — There is ambiguity in this method of measurement depending upon whether de-emphasis and/or limiting is used in the modulation system. For example:

a) if the maximum permissible frequency deviation is 5 kHz for any modulating frequency, then 30% is 1.5 kHz and the audio-frequency signal level that produces 1.5 kHz at 1 000 Hz is the reference signal level;

b) if the maximum permissible frequency deviation is 5 kHz at a modulating frequency of 3 000 Hz and if de-emphasis and/or limiting is not employed, the resulting deviation at a modulating frequency of 1 000 Hz is:

$$5\ \text{kHz} \times \frac{1\,000}{3\,000} = 1.66\ \text{kHz}$$

then 30% of the deviation for a modulating frequency of 1 000 Hz is 500 Hz.

The intention of this method of measurement is to prevent limiting or inadequate signal-to-noise ratios over the audio-frequency band to be measured. Either of the two methods cited may be useful, but alternative *a)* is preferred.

FIG. 9. — Measuring arrangement for modulation.

12.4 *Presentation of results*

Plot the deviation obtained in 12.2 and 12.3 on the linear ordinate versus audio-frequency on the logarithmic abscissa. The input signal level shall be stated.

Alternatively, the deviations may be plotted as variations from a specified characteristic.

13. Total distortion factor (of a sine-wave at audio frequencies)

13.1 *Definition*

The ratio, expressed as a percentage, of the r.m.s. value of a distorted sinusoidal signal without its fundamental component, to the r.m.s. value of the complete signal. The distorted sinusoidal signal includes harmonically related components, supply ripple and non-harmonically related components.

13.2 *Method of measurement*

a) Connect the equipment as illustrated in figure 9, page 35.

b) Adjust the audio-frequency generator (2) to produce standard test modulation.

c) Mesure the total distortion factor with a distortion factor meter (7) connected to the output of a modulation monitor (5) or a separate demodulator. The equipment used for measuring the distortion shall be preceded by a network having the appropriate de-emphasis characteristic and by the band-limiting filter described in appendix A.

If required, the measurement may be repeated with other values for the modulating frequency, with the same or other constant values for the resultant modulation level.

14. Relative audio-frequency intermodulation product level

14.1 *Definition*

The ratio, expressed in decibels, of:

a) the level of an unwanted, non-harmonic component present in the linearly demodulated output signal, as a result of transmitter non-linearity when two specified signals are applied to the input,

to

b) the level of the wanted, lower frequency, output signal.

14.2 *Method of measurement*

a) Connect the equipment as shown in figure 10, page 37.

b) In the absence of an output from the audio-frequency generator (2), adjust the audio-frequency generator (1) to obtain a modulation depth of 30% or 30% of the maximum permissible frequency (or phase) deviation at a modulating frequency F_1 of 1 000 Hz.

Record the output level of the generator (1).

c) Reduce the output of the generator (1) to zero and adjust the output of the generator (2) to obtain a modulation depth of 30% or 30% of the maximum permissible frequency (or phase) deviation at a modulating frequency F_2 of 1 600 Hz.

d) Restore the output of the generator (1) to the value recorded in step *b)*.

e) With the selective voltmeter, measure the level of each of the unwanted intermodulation products and of the wanted 1 000 Hz component at the output of the modulation monitor (7).

f) Correct the results to compensate for the amplitude-frequency response of the modulation monitor.

g) Calculate and record the ratio, in decibels, of each of the intermodulation product levels corrected as in step *f)* to the level of the 1 000 Hz component.

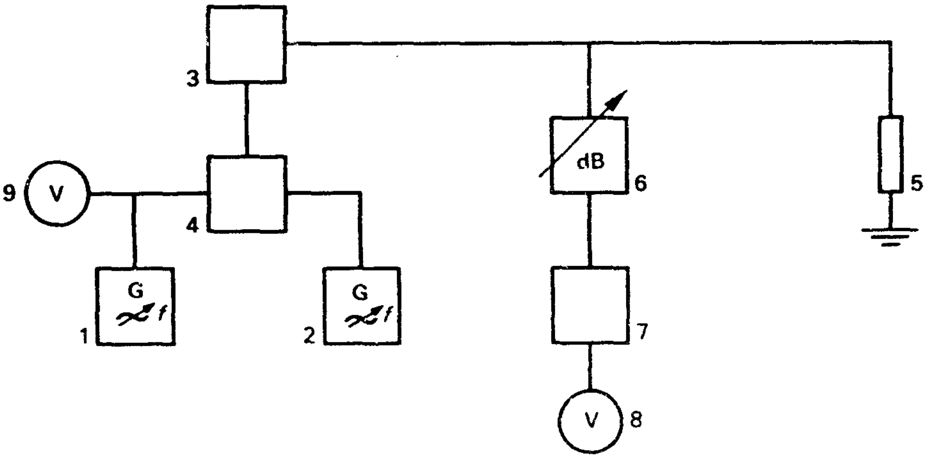
Notes 1. — The audio-frequency bandwith should be limited in accordance with appendix A of this standard.

2. — This method of measurement is valid for other modulating frequencies and other values of deviation.

3. — To ascertain that the two audio-frequency sources do not, by insufficient decoupling, produce intermodulation products which could have a detrimental effect on the accuracy of the measurement, it is recommended that the following test be carried out:

> Modify the arrangement of figure 10 by connecting the audio-frequency selective voltmeter (8) to the output of the combining unit (4) to measure the relative intermodulation product levels. These should be appreciably less than the relative level specified for the transmitter subjected to the test (−50 dB for instance if the specified level for the transmitter is −40 dB).

4. — The relative levels for the intermodulation products introduced by the modulation monitor (7) should be appreciably less than the relative level for the transmitter subjected to the test.



1 = audio-frequency generator No. 1
2 = audio-frequency generator No. 2
3 = transmitter under test
4 = audio-frequency combining unit
5 = test load
6 = coupler/attenuator
7 = modulation monitor
8 = audio-frequency selective voltmeter
9 = audio-frequency voltmeter

FIG. 10. — Example of an arrangement for measuring relative audio-frequency intermodulation product level.

14.3 *Presentation of results*

List the ratios recorded in step *g)* of 14.2 in a table, showing the frequencies at which they occur. State whether pre-emphasis has been incorporated in the transmitters.

Note. — The intended transmission system characteristics, for example any pre-emphasis and de-emphasis, should be taken into account in interpreting the results.

15. **Modulation limiting**

15.1 *Definition*

Modulation limiting is the process, usually accomplished in the audio-frequency stages, that prevents the modulation from exceeding the maximum permissible deviation.

15.2 *Method of measurement*

a) Connect the equipment as illustrated in figure 9, page 35.

b) Adjust the audio-frequency generator (2) to produce the standard test modulation.

c) Increase the input signal level by a specified amount, e.g. 10 dB, in one step.

d) Record the steady-state deviation.

e) With the input maintained at the value established in step *c)*, vary the audio-frequency over a specified frequency range and record the steady-state deviation at each frequency.

15.3 *Presentation of results*

Plot the deviation on the linear ordinate of a graph and the modulating frequency on the logarithmic abscissa.

16. **Residual modulation (due to hum and noise)**

16.1 *Residual frequency modulation*

16.1.1 *Definition*

The residual frequency modulation of the signal at the output of the transmitter, due to hum and noise, is the frequency modulation in the absence of any external modulating signal. It is expressed as the ratio in decibels of the output voltages of the modulation monitor with and without external modulation.

Note. — Some specifications may require the measuring equipment to be preceded by a band-limiting filter. See section one.

16.1.2 *Method of measurement*

a) Connect the equipment as illustrated in figure 11, page 39.

b) With the switch in the calibrate position, adjust the frequency-modulated signal generator (4) to a radio frequency equal to the nominal frequency of the transmitter under test and at a level of 60 dBµV. Modulate the generator with 1000 Hz at a frequency deviation of 1000 Hz.

c) Record the level U_c indicated on the r.m.s. voltmeter (8).

d) Switch the input of the FM monitor to the unmodulated transmitter under test and adjust its level to approximately 60 dBµV.

e) Record the residual noise and hum level U indicated on the r.m.s. voltmeter (8).

16.1.3. *Presentation of results*

Calculate the residual frequency modulation, N, expressed as a ratio, in decibels, relative to the deviation of 1000 Hz, from the formula:

$$N = 20 \log \frac{U}{U_c} \text{ (dB)}$$

16.2 *Residual amplitude modulation*

16.2.1 *Definition*

The amplitude modulation in the absence of any external modulating signal. It is expressed as the ratio, in decibels, of the output voltages of the amplitude modulation monitor with and without external modulation.

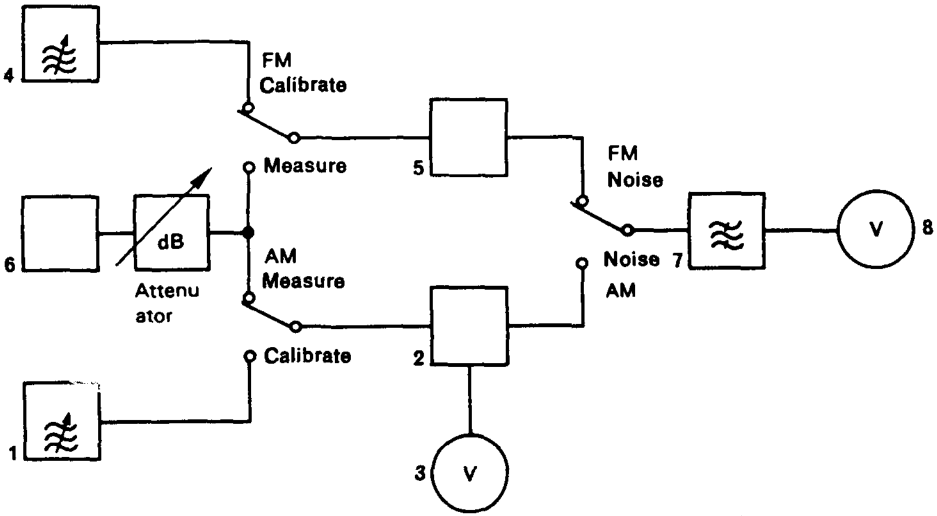
Note. — Some specifications may require the measuring equipment to be preceded by a band-limiting filter. See section one.

16.2.2 *Method of measurement*

a) Connect the equipment as illustrated in figure 11.

b) With the switch in the calibrate position, adjust the AM signal generator (1) to a radio frequency equal to the nominal frequency of the transmitter under test. Adjust its level to obtain a reference deflection on the d.c. component meter (3).

c) Modulate the AM generator (1) with 1000 Hz to a depth of 60%.



Legend
1 = amplitude-modulated signal generator
2 = amplitude-modulation monitor
3 = d.c. component meter
4 = frequency-modulated signal generator
5 = frequency-modulation monitor
6 = transmitter under test
7 = band-limiting filter
8 = true r.m.s. voltmeter (a.c. coupled)

FIG. 11. — Measuring arrangement for residual modulation.

d) Record the level U_c indicated on the r.m.s. voltmeter.

e) Switch the input of the AM monitor (2) to the unmodulated transmitter under test. Adjust the level of this signal until the d.c. component meter indicates the same reference deflection as noted in step *b)*. Record the residual noise and hum level U indicated on the r.m.s. meter.

16.2.3 *Presentation of results*

Calculate the AM noise and hum level, N, expressed as a ratio in decibels, to a modulation depth of 60% from the formula:

$$N = 20 \log \frac{U}{U_c} \text{ (dB)}$$

17. Transmitter attack time

17.1 *Definition*

The transmitter attack time is the elapsed time from:

1) the instant of changing the state of the transmitter from standby to transmit,

until

2) the instant at which the unmodulated carrier power reaches a value which is 3 dB below the steady-state value.

17.2 *Method of measurement*

a) Connect an oscilloscope, having a calibrated horizontal scan, in parallel with the test load to display the envelope of the transmitter output signal.

b) Simultaneously, initiate the transmit function and trigger the horizontal scan of the oscilloscope. Initiation of the transmit function may be by a voice-operated device.

c) The transmitter attack time is the elapsed time from the instant of initiating the transmit function until the envelope displayed on the oscilloscope reaches 70.7% of its steady-state value.

18. Transmitter performance under conditions deviating from standard test conditions

The performance of the transmitter can be evaluated under conditions deviating from standard test conditions.

The performance characteristics and the external conditions at which the measurements are made shall be those explicitly specified for this purpose in the equipment specification. The results can be compared with those obtained under standard conditions.

Some performance characteristics may reach a maximum degradation at some intermediate external condition and not necessarily at the extreme.

18.1 *Initial measurements under standard test conditions*

Before beginning the tests described in the following subclauses, the relevant performance characteristics should be evaluated first under the standard test conditions, in accordance with the methods detailed in this section.

No readjustment of the transmitter shall be made during the following tests.

18.2 *Variation of supply voltage*

The required characteristics shall be measured in accordance with the provisions of section eight of IEC 489-1.

18.3 *Variation of ambient temperature*

The measurements shall be made under the environmental conditions specified in section eight of IEC 489-1, with the following additional requirements.

18.3.1 *Cold*

After the equipment has been switched on, the required characteristics shall be measured, unless otherwise specified, after a 15 min standby warm-up, except for the frequency error which may be measured after the period of time stated in the equipment specification.

18.3.2 *Dry heat*

After the equipment has been switched on, the required characteristics shall be measured after a 15 min standby warm-up, except for the frequency error and the carrier power, unless otherwise specified, which shall be determined at intervals as stated in the equipment specification.

18.4 *Variation of relative humidity*

The required characteristics shall be measured under the environmental conditions specified in section eight of IEC 489-1.

After the equipment has been switched on, unless otherwise specified, the measurements, except for the frequency error, shall be made after a 15 min standby warm-up. Unless otherwise specified, the frequency error shall be determined after the minimum time stated in the equipment specification, if this minimum time is less than 15 min.

18.5 *Vibration*

For equipment intended to have immunity to vibration, the required characteristics shall be measured after the vibration test has been performed in conformity with 30.1 of IEC 489-1.

18.6 *Shock*

For equipment intended to have immunity to shock, the required characteristics shall be measured after the shock test has been performed in conformity with 30.2 of IEC 489-1.

18.7 *Drop (free fall)*

For personal equipment intended to have immunity to damage from drop, the required characteristics shall be measured after the drop test has been performed in conformity with 30.3 of IEC 489-1.

18.8 *Dust and sand*

For equipment intended to have immunity to dust and sand, the required characteristics shall be measured after the dust and sand test has been performed in conformity with 30.4 of IEC 489-1.

18.9 *Driving rain*

For equipment intended to have immunity to driving rain together with strong wind, the required characteristics shall be measured after the driving rain test has been performed in conformity with 30.5 of IEC 489-1.

18.10 *Corrosion (salt fog)*

For equipment intended to have immunity to corrosion (salt fog), the required characteristics shall be measured after the corrosion test has been performed in conformity with 30.6 of IEC 489-1.

APPENDIX A

RECOMMENDED CHARACTERISTICS OF THE MEASURING EQUIPMENT

A1. Modulation monitor

The modulation monitor shall be capable of indicating with an accuracy of 5%:

a) the peak positive and negative amplitude deviations of the carrier, for amplitude modulation measurements,

and/or

b) the peak positive and negative frequency deviation from the carrier frequency, for angle modulation measurements.

Output terminals should be provided for the demodulated signal.

A2. True r.m.s. voltage meters

For the measurement of the signal-to-noise ratio, the characteristics of the indicating meter are important. In addition, for certain characteristics, measurement of the true r.m.s. voltage is required.

A3. Distortion-factor meter or SINAD meter

The distortion-factor meter or SINAD meter shall have the following characteristics:

- The wide-band response shall not vary by more than 0.1dB over the frequency range 50 Hz to 20000 Hz.
- The band elimination filter attenuation shall be at least 40 dB at 1000 Hz, but not more than 0.5 dB between 50 Hz and 500 Hz, and between 2000 Hz and 20000 Hz.

  If the SINAD meter has a fixed filter, it shall have 40 dB attenuation over the frequency band of 980 Hz to 1020 Hz.
- The noise signal level from a constant amplitude noise source between 300 Hz and 3000 Hz shall not be attenuated by more than 1 dB by the filter.
- The indicator shall be a true r.m.s. type for a crest factor of 3 or less.

Note. — As a result of the different characteristics of the band elimination filters, the measurement results obtained with the distortion-factor meter or SINAD meter specified above may differ from those obtained with the measuring equipment specified in the previous edition of this standard.

A4. Selective measuring device

The selective measuring device may be either a frequency selective voltmeter, a spectrum analyzer, or a calibrated field-strength meter. The bandwidth of the measuring device shall be appropriate for the measurement being made or shall be adjusted to the value stated in the method of measurement.

A5. Audio-frequency band-limiting filter

Unless otherwise specified, the upper cut-off frequency of the audio-frequency band-limiting filter shall be about three times the upper frequency limit of the band of modulation frequencies specified for the transmitter. The lower cut-off frequency shall be the lowest modulation frequency specified, with an allowable attenuation of 3 dB at the cut-off frequency.

To be effective, the attenuation slope of the filter shall be at least 12 dB/octave.

A6. Standard test receiver

The standard test receiver shall be designed to receive signals of the emission class produced by the transmitter under test. Its selectivity, Type B1, shall be measured according to IEC 489-3, except that the unwanted signal shall be unmodulated.

The minimum selectivity slope, between the points where the ratios of the unwanted to the wanted signals are 6 dB and 85 dB, shall be determined by the channel spacing as follows:

Channel spacings	*Minimum selectivity slope*
≦15 kHz	12 dB/kHz
>15 kHz	6 dB/kHz

The bandwidth at the unwanted-to-wanted input signal ratio of 6 dB shall be indicated.

A7. Power measuring receiver

The adjacent-channel power of transmitters can be measured with a power measuring receiver. Block diagrams for a measuring arrangement which is referred to as a power measuring receiver are shown in figures 4 and 7, pages 19 and 31.

The power measuring receiver shall be capable of measuring the ratio of the carrier power to the adjacent-channel power with an accuracy of ±3 dB. The following characteristics of the power measuring receiver are required to meet this accuracy:

- The measurement of the reference frequencies and the setting of the local oscillator (4A) frequency shall be within ±50 Hz.
- The linearity of the power measuring receiver shall be such that an error in the reading of not more than 1.5 dB will be obtained over an input level variation of 100 dB.
- The i.f. attenuator (4C) shall be adjustable over a range of 80 dB.
- The combination of attenuator and meter shall permit 0.5 dB reading resolution.

- The r.m.s. meter shall have a crest factor of at least 10.
- Ideally, the power measuring receiver should have a rectangular selectivity characteristic. This can be approached with a power measuring receiver having an amplitude and frequency characteristic shown in figure A1 and in table A1 of this appendix.
- The error due to the noise of the local oscillator, of mixer (4A) and any amplifiers shall be less than 1.3 dB. This noise will limit the maximum ratio that can be measured, e.g. 80 dB unless exceptional measures are taken to minimize the noise level.

The error in the measurement due to noise will be acceptable if the noise power of the power measuring receiver is less than one-fourth (−6 dB) of the total power at the output of the power measuring receiver.

To verify that the power measuring receiver meets this requirement:

a) Connect a signal source having a noise power density approximately 140 dB/Hz (see note) relative to the signal level at the adjacent-channel spacing to the input of the power measuring receiver.

Note.— The maximum value of the noise power density, expressed in decibels/hertz relative to the output power of the signal source, and which may not be exceeded when a specific adjacent-channel power ratio has to be measured, is given by the following relationship:

dB/Hz (signal source) = $-A - 10 \log B - 6$

where:

A is the required adjacent-channel power ratio in decibels

B is the power measuring receiver bandwidth in hertz

b) Measure the adjacent-channel power of the signal source as per 8.5.2 or 9.5.2 of this standard.

The greatest ratio that may be measured on a transmitter is 6 dB less than the value measured in step *b)*.

TABLE A1

Table for selectivity limits for power measuring receiver

Point	Attenuation (dB)	Displacement from "reference frequency"**			Bandwidth characteristics*			Tolerances (kHz)		
		Filter 6 dB bandwidth			Filter 6 dB bandwidth			Filter 6 dB bandwidth		
		6−8.5	14	16	6−8.5	14	16	6−8.5	14	16
D1	2	1.25	3	3	6	8	10	±2	±3	±3.5
D2	6	0	0	0	8.5	14	16	±2	±3	±3.5
D3	26	−1.25	−1.25	−1.25	11	16.5	18.5	±2	±3	±3.5
D4	90	−5.25	−5.25	−5.25	19	24.5	26.5	±2 −6	+3 −7	±3.5 −7.5

* Values usually specified in national regulations.

** The "reference frequency" is the frequency at which the attenuation is 6 dB on the side close to the carrier (point D2).

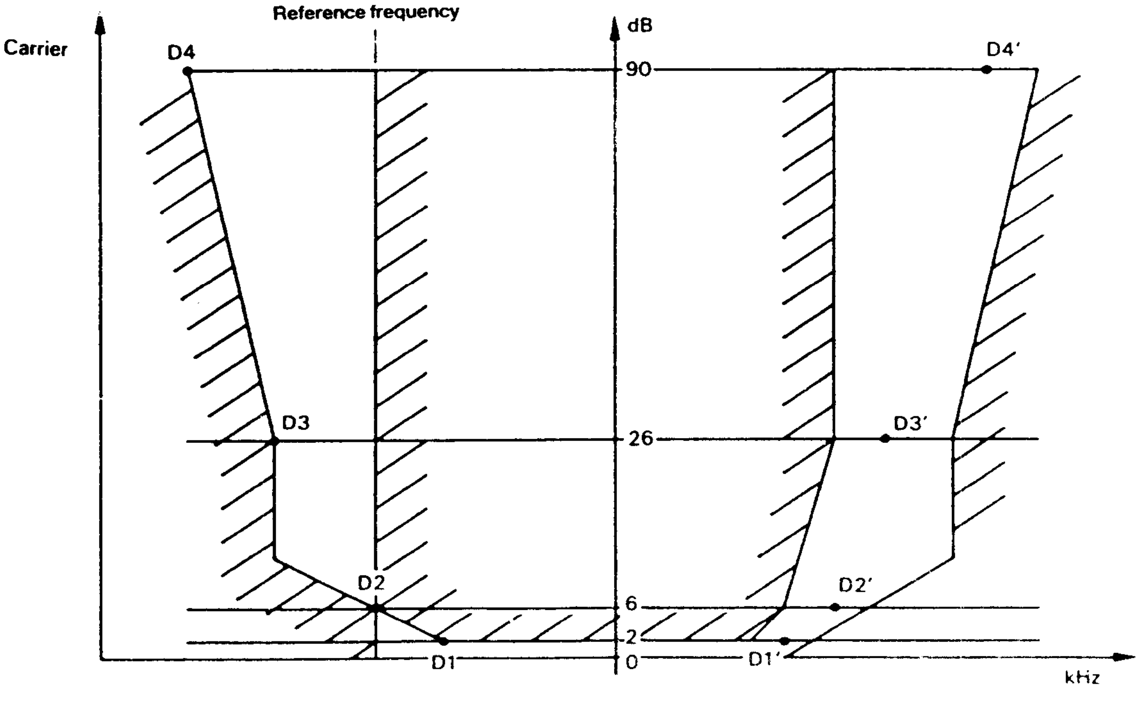


FIG. A1. — Selectivity limits for power measuring receiver.

A8. Spectrum analyzer

A8.1 *Spectrum analyzer for use in the adjacent channel power measurement*

A spectrum analyzer is an equipment which allows the display of the power or the amplitude of a signal versus frequency.

Some spectrum analyzers are equipped with digital sampling devices. They can digitize and store values representing the indications shown on the display. Typically up to 1 000 samples are stored and the data samples are available for processing.

A8.2 *Spectrum analyzer noise power performance*

In principle, spectrum analyzers have a noise power sufficiently low so as not to hinder adjacent channel power measurements on transmitters. With any type of spectrum analyzer, the total noise power due to the spectrum analyzer and the transmitter allows for measurements of adjacent channel power ratios up to:

10 lg (carrier power/noise power in the selected resolution bandwidth) −3 dB.

where the noise power in the selected resolution bandwidth is the sideband noise power (see note below) of the spectrum analyzer specified in a 1 Hz bandwidth centered on an offset from the carrier equal to the specified channel spacing, multiplied by the noise bandwidth of the selected resolution bandwidth of the spectrum analyzer.

Note. — The value of the sideband noise power is normally given in the technical specification of the spectrum analyzer.

With digital storage spectrum analyzers, the residual noise power due to the transmitter is taken into account in the measurement. Therefore, the noise power due to the spectrum analyzer allows for measurements of adjacent channel power ratios up to:

10 lg (carrier power/noise power in the specified adjacent bandwidth) −3 dB

where the noise power in the specified adjacent bandwidth is the sideband noise power of the spectrum analyzer specified in a 1 Hz bandwidth centred on an offset from the carrier equal to the specified channel spacing, multiplied by the specified bandwidth.

A8.3 *Maximum adjacent channel power ratio (digital storage spectrum analyzer)*

Where the noise power of the digital storage spectrum analyzer is not specified, the following measuring method can be used to determine the suitability of the analyzer for adjacent channel power ratio measurement. The measurement method requires the use of a signal generator with a specified noise power performance at the carrier frequency of interest of better than − 120 dB (referred to the carrier)/Hz at an offset equal to the channel spacing of the radio equipment to be tested.

a) Connect the output of the signal generator directly to the input of the digital storage spectrum analyzer.

b) Adjust the signal generator to produce an unmodulated output of 0 dBm at a frequency equal to that of the transmitter the analyzer will be expected to measure.

c) Adjust the spectrum analyzer as follows:

- resolution and video bandwidth to the lowest possible setting, but not less than the specified bandwidth divided by 200 nor greater than the specified bandwidth divided by 40 and record this as R;

- total swept bandwidth to the lowest possible setting which is equal to or greater than the specified bandwidth and record this as B;
- the sweep time to greater than $3B/R^2$.

Note. — The specified bandwidth is that which is applicable to the intended adjacent channel power ratio measurement.

d) Adjust the digital storage spectrum analyzer so that the centre of the displayed figure coincides with the carrier frequency of the signal generator.

e) Adjust the sensitivity of the digital storage spectrum analyzer to a value which provides a displayed figure on the screen which is in the linear range of the spectrum analyzer. Activate the digital storage spectrum analyzer to record the values C_i in dBm for at least 200 samples uniformly distributed throughout the specified bandwidth.

Calculate and record the indicated carrier power P_c using the following relationship:

$$P_c = 10 \lg \sum_{i=1}^{i=n} 10^{C_i/10} \quad \text{dBm}$$

where n is the number of samples

f) Adjust the digital storage spectrum analyzer so that the centre of the displayed figure coincides with the centre frequency of the upper adjacent channel.

g) Activate the digital storage spectrum analyzer to record the values A_n in dBm for the same number of samples used in step *e)* uniformly distributed throughout the specified bandwidth. Calculate and record the indicated adjacent channel power P_a using the following relationship:

$$P_a = 10 \lg \sum_{i=1}^{i=n} 10^{A_i/10} \quad \text{dBm}$$

where n is the number of samples

h) Calculate the maximum adjacent channel power ratio using the following relationship:

$$PR = P_c - P_a - 3\ \text{dB}$$

where:

P_c is the value recorded in step *e)*

P_a is the value recorded in step *g)*

Where the maximum adjacent channel power ratio calculated in step *h)* exceeds the limit measurement requirement for adjacent channel power ratio, then the digital storage spectrum analyzer measurement method may be used.

APPENDIX B

GUIDE FOR THE CONSTRUCTION OF A 30 m RADIATION TEST SITE FOR EQUIPMENT EMITTING RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

Emission measurements can be made for all radio-frequency parameters pertaining to radiated radio-frequency electromagnetic energy, for example, transmitter radiated power, transmittei radiated spurious power, receiver radiated spurious power.

B1. Test site characteristics

	Limits
Useful frequency range:	25 MHz to 1 000 MHz
Nominal site attenuation:	20 dB to 46 dB for 25 MHz 52 dB to 78 dB for 1 000 MHz

Note. — The nominal attenuation of the test site for a half-wave dipole is 26 dB for 25 MHz and 58 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.

	Limits
Equipment size:	6 m maximum, excluding the antenna
Radiation angle:	Only apply to the horizontal plane

B2. Radiation test site

The radiation test site shall be on level ground having uniform electrical characteristics and be free from reflecting objects over as wide an area as possible to ensure that extraneous electromagnetic fields do not affect the accuracy of the test results.

The minimum boundary of the test site shall be an ellipse having a 60 m major axis and a 52 m minor axis. The equipment under test and the transmitting antenna shall be located at the foci.

No extraneous conducting objects having any dimension in excess of 15 cm for measurements over the frequency range of 25 MHz to 300 MHz, or 5 cm for measurements over the frequency range of 300 MHz to 1 GHz, shall be in the immediate vicinity of the equipment under test or the transmitting antenna.

The distance between the vertical axis through the centre of the antenna of the equipment under test and the vertical axis through the centre of the transmitting antenna shall be 30 m.

All test equipment if located above ground shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

B3. Position of the equipment under test (see figure B1, page 49)

A pedestal shall be placed on a turntable so that the pedestal's upper horizontal surface is 1.5 m above ground. The equipment under test in the cabinet or housing in which it normally operates shall be placed on the upper horizontal surface of the pedestal. Both the turntable and the pedestal shall be made of non-conducting materials.

For equipment having an integral antenna, place the equipment on the pedestal in a position which is closest to its position in normal use.

For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

For equipment having a non-rigid external integral antenna, mount the antenna vertically with a non-conducting support.

If the equipment has a power cable, it should extend down to the turntable, and any excess cable length should be coiled on the turntable.

B4. Measuring antenna support

The measuring antenna support shall consist of a horizontal boom supported by a vertical mast, both made of non-conducting materials. The boom shall project at least 1 m from the vertical mast in the direction of the equipment under test and shall be arranged so that it may be raised and lowered between 1 m and 4 m.

B5. Measuring antenna

The measuring antenna shall be suitable for the reception of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, or to increase the sensitivity of the measurements, it may be preferable to use a number of separate fixed broadband dipoles or more complex antennas.

The measuring antenna shall be mounted at the end of a horizontal boom. The mounting shall permit the antenna to be positioned for measuring both the horizontal and the vertical components of the electrical field. The lower end of the antenna when oriented for vertical polarization and placed in its lowest position shall be at least 0.3 m above the ground.

The cable from the antenna shall be routed along the horizontal boom for at least 3 m and should preferably extend, while being at ground level, at least 3 m beyond the minimum boundary of the test site before it is connected to the selective measuring device. Alternatively, the cable may be routed underground.

B6. Auxiliary antenna

The auxiliary antenna replaces the equipment under test during part of the measurement. The auxiliary antenna shall be a half-wave dipole and shall be arranged in a manner similar to that of the measuring antenna, except that the centre of the auxiliary antenna should coincide approximately with the normal position of the centre of radiation of the equipment under test.

At frequencies below about 60 MHz, the above condition is impossible to achieve when the antenna is arranged for vertical polarization. In this case, the lower end of the dipole shall be placed 0.3 m above ground.

B7. Radio-frequency signal generator

A well-shielded radio-frequency signal generator, with a matching or combining network (if required) and its associated output cable, shall be placed in a position such that it will not affect the accuracy of the test results and shall be connected and matched to the auxiliary antenna.

B8. Selective measuring device

The selective measuring device may be either a frequency selective voltmeter, a spectrum analyzer or a calibrated field-strength meter, and shall be placed, together with its associated input cable, in a position such that it shall not affect the accuracy of the test results.

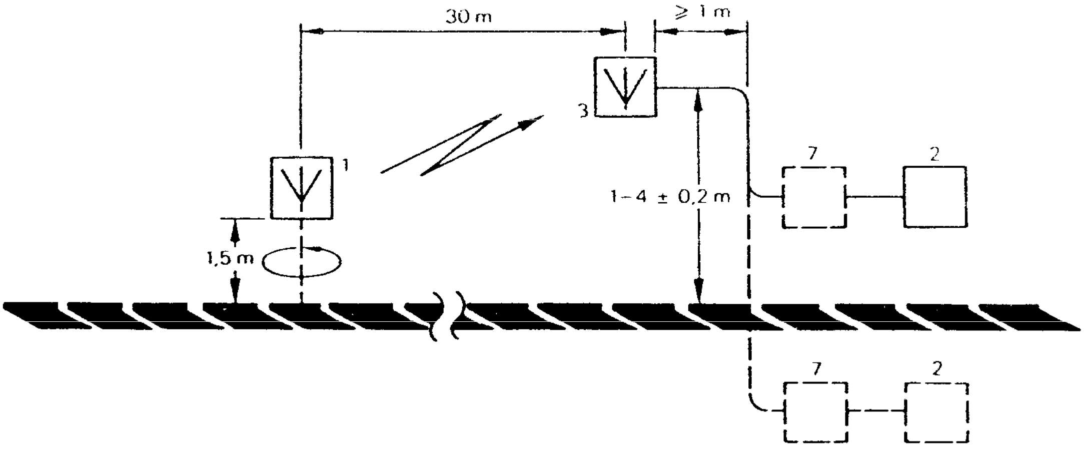


FIG. B1a

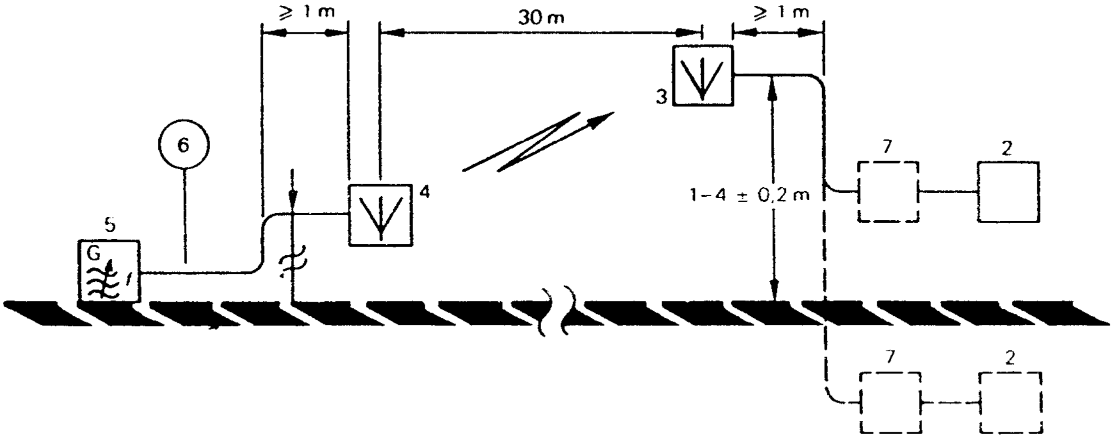


FIG. B1b

Legend

1 – equipment under test
2 – selective measuring device
3 – measuring antenna
4 – auxiliary antenna
5 – radio-frequency signal generator

6 – selective measuring device
7 – optional calibrated attenuator for measuring the effective radiated power, or fundamental oscillation rejection filter for measuring non-essential emissions

FIG. B1. — Measuring arrangement for equipment emitting radio-frequency electromagnetic energy (30 m).

APPENDIX C

EXAMPLE OF A MAINS POWER LINE IMPEDANCE STABILIZATION NETWORK

C1. Introduction

A mains power line impedance stabilization network (also known as artificial mains network) is required to provide defined impedances at high frequencies between the mains terminals of the transmitters and between each of these terminals and earth. The network also provides a suitable filter to isolate the transmitter circuit from unwanted radio-frequency voltages that may be present on the supply mains.

The impedance of this filter section at the measuring frequency shall be sufficiently high for the combination of filter and associated network as represented in figure C1, page 52, to give an impedance having a modulus of $150 \pm 20\ \Omega$ and a phase angle not exceeding 20°, both between the terminals of the transmitter and, between these two terminals connected together, and earth.

The symmetrical voltage is the voltage appearing between terminals A and B (see figure C1).

The asymmetrical voltage is the voltage appearing between terminal C and the earth (see figure C1).

These voltages may be represented in a theoretical vector diagram as indicated in figure C2, page 52.

C2. Method of measuring interference voltage

For practical measurements, a mains power line impedance stabilization network, similar to the example given in figure C3, page 52, may be used. This network is suitable for measuring both symmetrical (position 1 of switch S) and asymmetrical (position 2 of switch S) components, with an unbalanced selective voltmeter.

TABLE CI

Resistance, attenuation and impedance values of the artificial mains network of figure C3, page 52 (note 1), for three different input impedances, Z, of the measuring equipment			
	$Z = 50\,\Omega$	$Z = 60\,\Omega$	$Z = 75\,\Omega$
Resistance (note 2)			
$R_1 = R_2$	118.7 (120) Ω	112.2 (110) Ω	107.1 (110) Ω
$R_3 = R_5$	152.9 (150) Ω	169.7 (160) Ω	187.5 (180) Ω
R_4	390.7 (390) Ω	483.9 (470) Ω	621.4 (620) Ω
$R_6 = R_7$	275.7 (270) Ω	230.3 (220) Ω	187.5 (180) Ω
$R_8 = R_9$	22.8 (22) Ω	27.6 (27) Ω	34.5 (36) Ω
$R_{10} = R_{11}$	107.8 (110) Ω	129.1 (130) Ω	161.3 (150) Ω
R_{12}	50 Ω	60 Ω	75 Ω
Attenuation (note 3)			
Symmetrical A_{sym}	20 (20) dB	20 (19.7) dB	20 (19.8) dB
Asymmetrical A_{asym}	20 (19.9) dB	20 (19.8) dB	20 (20) dB
Artificial mains network impedance (note 3)			
Symmetrical Z_{sym}	150 (150) Ω	150 (145.7) Ω	150 (151.2) Ω
Asymmetrical Z_{asym}	150 (148) Ω	150 (143.4) Ω	150 (145.2) Ω

Notes 1. – The ratio of turns of the balanced to unbalanced transformer in figure C3 is assumed to be $\frac{\sqrt{2.5}}{1}$ with centre tap.

2. – Resistance values shown in brackets are the nearest preferred values (tolerance ± 5%).

3. – Values shown in brackets are calculated, using the preferred resistance values nearest to the theoretical values.

Allowance shall be made for the attenuation introduced by this network. For all pertinent values, refer to figure C3 and table CI in this appendix.

An additional filter section may be required in the case where mains-borne radio-frequency interference influences the measurements to a substantial extent.

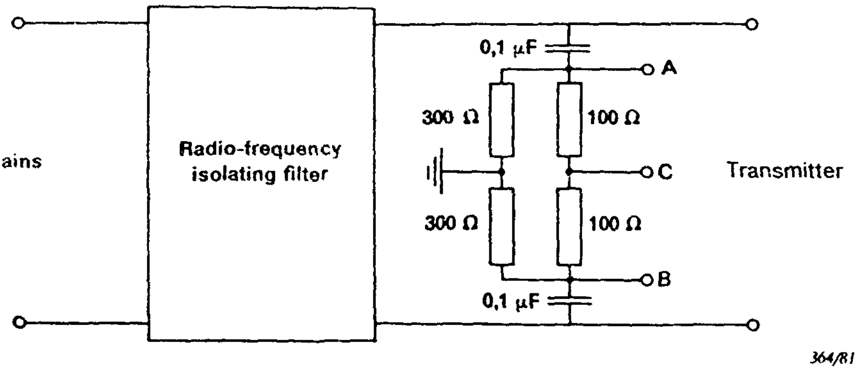


FIG. C1. — Mains power line impedance stabilization network (also known as artificial mains network).

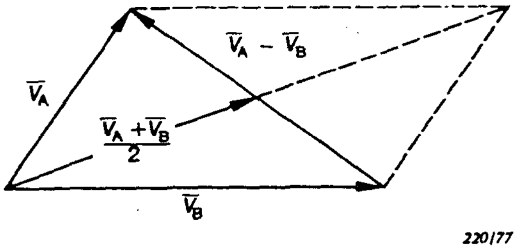
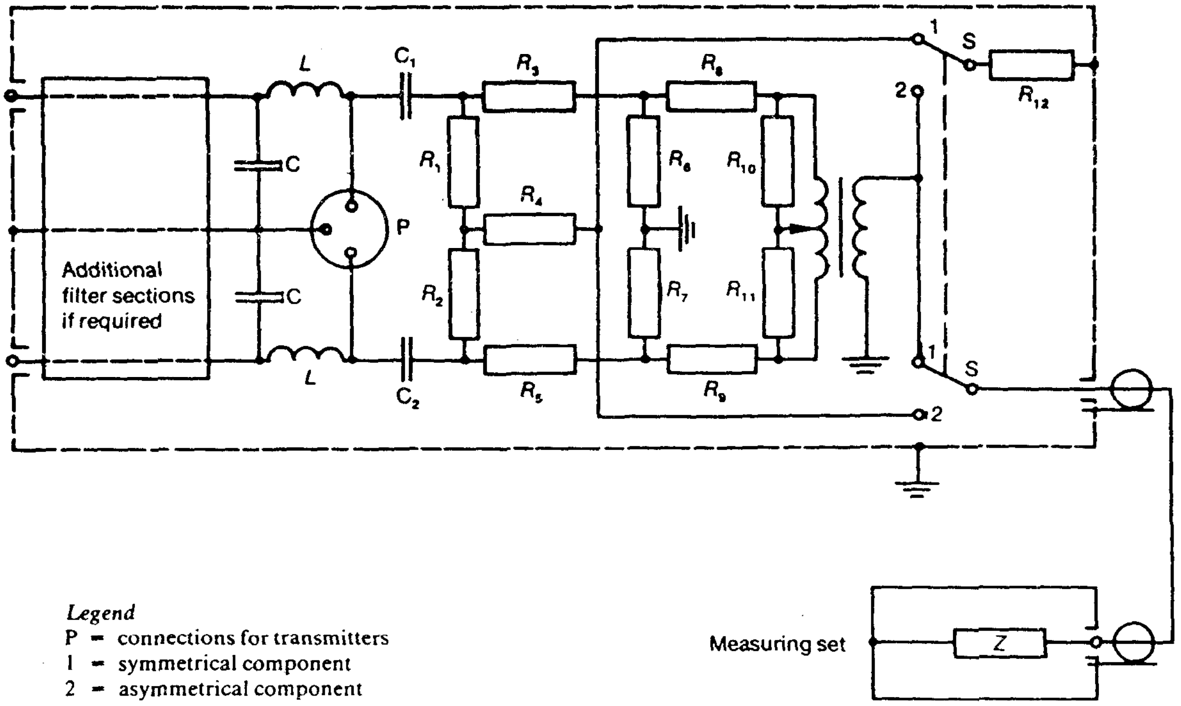

$\overline{V}_A - \overline{V}_B$
$\overline{V}_A$
$\frac{\overline{V}_A + \overline{V}_B}{2}$
$\overline{V}_B$
220/77

FIG. C2. — Vector diagram of interference voltages.



Legend
P = connections for transmitters
1 = symmetrical component
2 = asymmetrical component

FIG. C3. — Example of a mains power line impedance stabilization network.

APPENDIX D

GUIDE FOR THE CONSTRUCTION OF A 3 m RADIATION TEST SITE FOR MEASUREMENTS ABOVE 100 MHz OF EQUIPMENT EMITTING RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

Emission measurements can be made for all radio-frequency parameters pertaining to radiated radio-frequency electromagnetic energy, for example, transmitter radiated power, transmitter radiated spurious power, receiver radiated spurious power.

D1. Test site characteristics

	Limits
Useful frequency range:	100 MHz to 1 000 MHz
Nominal site attenuation:	12 dB to 38 dB for 100 MHz 32 dB to 58 dB for 1 000 MHz

Note. — The nominal attenuation of the test site for a half-wave dipole is 18 dB for 100 MHz and 38 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.

	Limits
Equipment size:	6 m maximum, excluding the antenna
Radiation angle:	+40° to −10°

D2. Radiation test site

The 3 m test site described in this standard provides consistent results regardless of time or location. It permits an accuracy over the useful frequency range comparable to that achievable on larger test sites while requiring less sensitive instrumentation than on those larger sites.

The radiation test site shall be on level ground having uniform electrical characteristics and be free from reflecting objects over as wide an area as possible to ensure that extraneous electromagnetic fields do not affect the accuracy of the test results.

A continuous ground screen (either sheet metal or wire mesh having openings of no greater than 1 cm, in order to maintain good electrical contact between the wires) shall be used to establish a uniformly conducting ground over part of the test site. The minimum ground screen area is shown in figure D1, page 55.

No extraneous conducting objects having any dimensions in excess of 5 cm shall be present within the minimum ground screen boundary. Objects between the minimum ground screen boundary and the test site boundary shall not be such as to affect the test results.

The test site shall have a turntable and a measuring antenna mast. The distance in the horizontal plane between the vertical axis through the centre of the turntable and the vertical axis through the centre of the measuring antenna mounted on the measuring antenna mast shall be 3 m. A shelter may be provided for all or part of the test site. All such construction (except for nails, hinges, etc., having no dimension greater than 5 cm) shall be of wood, plastic, or other non-conducting material. The wood should be impregnated to ensure minimum water absorption.

All test equipment if located above ground shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio-frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

D3. **Position of the equipment under test** (see figure D2, page 56)

The equipment in its cabinet or the housing in which it normally operates shall be placed on a horizontal platform, the upper side of which is 1.5 m above the ground. The platform and its support shall be made of non-conducting materials.

For equipment having an integral antenna, place the equipment on the platform in a position which is closest to its position in normal use.

For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

For equipment having a non-rigid external integral antenna, mount the antenna vertically with a non-conducting support.

It shall be possible to rotate the equipment about the vertical axis through the centre of the antenna of the equipment under test. It is recommended that a platform in the form of a turntable, preferably remotely controlled, should be used for this purpose.

If the equipment has a power cable, it should extend down to the turntable, and any excess cable length should be coiled on the turntable.

D4. **Measuring antenna support**

The measuring antenna support shall consist of a horizontal boom supported by a vertical mast, both made of non-conducting materials. The boom shall project at least 1 m from the vertical mast in the direction of the equipment under test and shall be arranged so that it may be raised and lowered between 1 m and 4 m.

D5. **Measuring antenna**

The measuring antenna shall be suitable for the reception of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, or to increase the sensitivity of the measurements, it may be preferable to use a number of separate fixed broadband dipoles or more complex antennas.

The measuring antenna shall be mounted at the end of a horizontal boom. The mounting shall permit the antenna to be positioned for measuring both the horizontal and the vertical components of the electrical field. The lower end of the antenna when oriented for vertical polarization and placed in its lowest position shall be at least 0.3 m above the ground.

The cable from the antenna shall be routed along the horizontal boom for at least 3 m and should preferably extend, while being at ground level, at least 3 m beyond the minimum boundary of the test site before it is connected to the selective measuring device. Alternatively, the cable may be routed underground.

D6. **Auxiliary antenna**

The auxiliary antenna replaces the equipment under test during part of the measurement. The auxiliary antenna shall be a half-wave dipole and shall be arranged in a manner similar to that of the measuring antenna, except that the centre of the auxiliary antenna should coincide approximately with the normal position of the centre of radiation of the equipment under test.

D7. Radio-frequency signal generator

A well-shielded radio-frequency signal generator, with a matching or combining network (if required) and its associated output cable, shall be placed in a position such that it will not affect the accuracy of the test results, and shall be connected and matched to the auxiliary antenna.

D8. Selective measuring device

The selective measuring device may be a frequency selective voltmeter, a spectrum analyzer or a calibrated field-strength meter, and shall be placed, together with its associated input cable, in a position such that it shall not affect the accuracy of the test results.

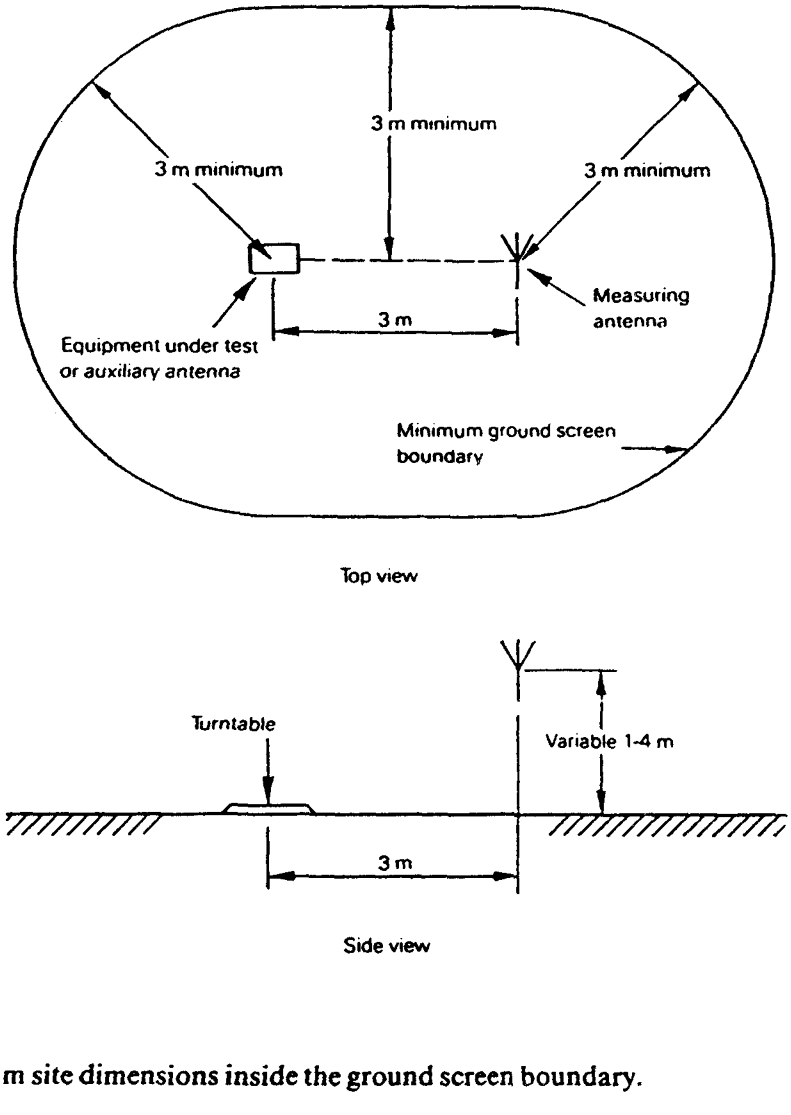


FIG. D1. — 3 m site dimensions inside the ground screen boundary.

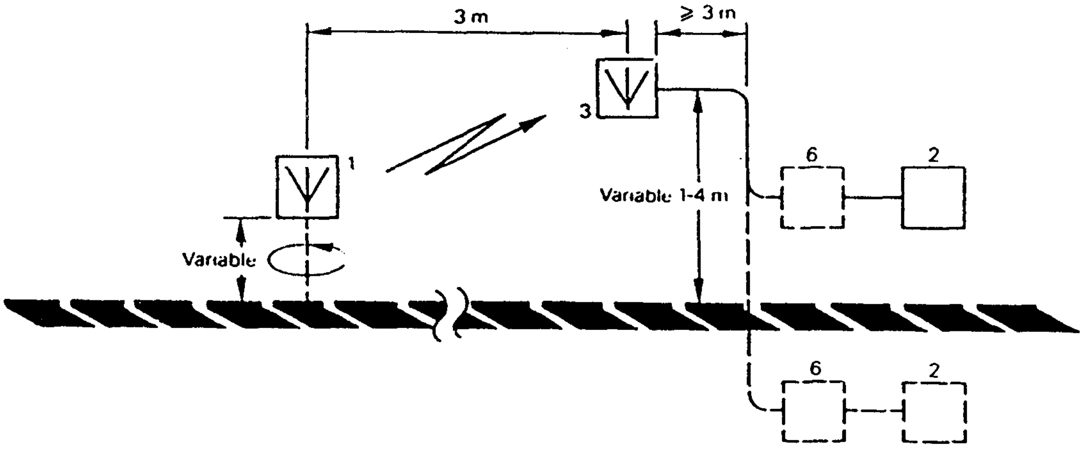


FIG. D2a. — Measuring arrangement for the equipment under test.

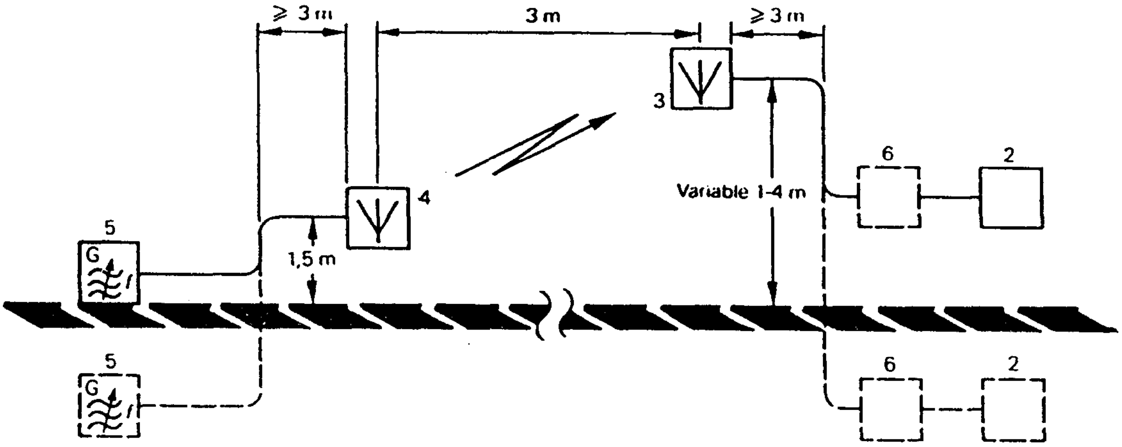


FIG. D2b. — Measuring arrangement for substitution measurement.

Legend

1 = equipment under test
2 = selective measuring device
3 = measuring antenna
4 = auxiliary antenna
5 = radio-frequency signal generator

6 = optional calibrated attenuator for measuring the effective radiated power, or fundamental oscillation rejection filter for measuring non-essential emissions

FIG. D2. — Measuring arrangement foı equipment emitting radio-frequency electro-magnetic energy (3 m).

(Continued from second cover page)

(1991) as well as to take into account the latest technological developments in this field.

The text of the IEC standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not indentical to those used in Indian Standards. Attention is particualarly drawn to the following:

> Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

CROSS REFERENCES

In this Indian Standard, the following International Standards are referred to. Read in their respective places the following:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 244-1(1968) Methods of measurement for radiotransmitters : Part 1 General conditions of measurement, frequency, output power and power consumption	IS 10853 (Part 1) : 1984 Methods of measurement for radio transmitters : Part 1 General conditions of measurement	Technically equivalent
IEC 489-1(1983) Methods of measurement for radio equipment used in the mobile services : Part 1 General definitions and conditions of measurement	IS 10820 (Part 1) : 1984 Methods of measurement for radio equipment used in mobile services : Part 1 General definitions and conditions of measurement	Technically equivalent

The concerned technical committee has reviewed the provisions of following standards referred in this adopted standard and has decided that these are acceptable for use in conjunction with this standard:

(1) IEC 244-6 (1976) : Methods of measurement for radio transmitters : Part 6 Cabinet radiation at frequencies between 130 kHz and 1 GHz.

(2) IEC 489-3 (1988) : Methods of measurement for radio equipment used in the mobile services : Part 3 Receivers for A3E or F3E.

(3) CISPR 13 (1990) : Limits and methods of measurement of radio interference characteristics of sound and television broadcast receivers and associated equipment.

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

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